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Bridging the Gap between HL7 CDA and HL7 FHIR: A JSON Based Mapping

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Abstract. The Austrian electronic health record (EHR) system ELGA went live in December 2016. It is a document oriented EHR system and is based on the HL7 Clinical Document Architecture (CDA). The HL7 Fast Healthcare Interoperability Resources (FHIR) is a relatively new standard that combines the advantages of HL7 messages and CDA Documents. In order to offer easier access to information stored in ELGA we present a method based on adapted FHIR resources to map CDA documents to FHIR resources. A proof-of-concept tool using Java, the open-source FHIR framework HAPI-FHIR and publicly available FHIR servers was created to evaluate the presented mapping. In contrast to other approaches the close resemblance of the mapping file to the FHIR specification allows existing FHIR infrastructure to be reused. In order to reduce information overload and facilitate the access to CDA documents, FHIR could offer a standardized way to query CDA data on a fine granular base in Austria.

Keywords. Electronic Health Records, HL7 CDA, HL7 FHIR.

1. Introduction

In December 2015 the Austrian electronic health record system - Elektronische Gesundheitsakte (ELGA) - went live in two Austrian test regions. ELGA is designed as a distributed system to exchange medical documents with central components for identification of patients and health care providers and authorization management [1]. The Health Level Seven International (HL7) Clinical Document Architecture (CDA) [2] is used to exchange and persist medical information (i.e. ELGA adopts a document centric view). Currently four different document types (i.e. “Physician’s Discharge Summary”, “Nursing Discharge Summary”, “Laboratory Report” and “Diagnostic Imaging Report”) are available in the ELGA system. In July 2016 the first “e-Medication report” including prescription, dispensing, medication summary and pharmaceutical advice will be available in ELGA. By summer 2016 ELGA will be operational in all Austrian provinces.

The current architecture to exchange medical information in ELGA is based on the *Integrating the Healthcare Enterprise* (IHE) *Cross-Enterprise Document Sharing* (XDS) profile [3] and CDA. This architecture was first proposed in a feasibility study in 2006 [4]. IHE XDS is a distributed architecture and is used in different regions and countries worldwide [5]. Despite the widespread use of IHE XDS and its practical significance, IHE XDS is very much restricted in its search capabilities due to the following three reasons: First, IHE XDS only allows coarse filtering of medical documents via a limited

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set of document metadata (e.g., patient, author, date, type of document) and only complete documents are returned as the result of a query [6]. Second, IHE XDS uses the Simple Object Access Protocol (SOAP), which works well in server environments, but due to its complexity is rarely used in the mobile world. This was no problem a decade ago, but the IT landscape has since changed significantly and the use of mobile internet access overtook the fixed internet access in 2014 [7]. Third, CDA documents are predestined to replace paper-based documentation adapting a similar process as paper based approaches to persist and sign documents in the digital world. Yet the experience has shown that CDA is difficult to implement due to the complexity in its specification in combination with the additional layer of constraints from specific CDA implementations (e.g. ELGA document types).

HL7 Fast Healthcare Interoperability Resources (FHIR) [8] is a relatively new HL7 initiative that combines the advantages of the HL7 v2/v3 messages and CDA documents. It is based on the Representational State Transfer (REST) architectural style [9], which was specifically designed for thin clients like web browsers as well as fast and easy implementation. FHIR uses modular components called Resources to exchange, query, load, persist or delete health information on a granular level. FHIR resources are serialized using the Extensible Markup Language (XML) or the Java Script Object Notation (JSON), converters between the two formats exits.

The easy implementation of FHIR in combination with good documentation and open source reference implementations available has led to a wide adoption of FHIR[10, 11]. FHIR is also used as a connector to existing health data infrastructures like i2b2 [12] or openMRS [13]. To allow mobile devices or other resource constrained systems to access IHE XDS health information, IHE created the *Mobile access to Health Documents* (MHD) profile. MHD is currently on hold and the profile will be updated to reflect the changes made in new FHIR standard once FHIR reaches a stable point [14].

The goal of the present work was to allow easier access to health data stored in ELGA CDA documents. We present a mechanism based on adapted FHIR resources to map and transform ELGA CDA documents to FHIR resources. This can enable various stakeholders like health care providers, patients, app developers and researchers to access ELGA compliant data more easily. The approach was tested using ELGA e-Medication documents and a proof-of-concept Java implementation.

2. Methods

To formalize the mapping of CDA documents to FHIR resources in a computer processable format we used JSON. In order to simplify the initial setup of the mapping file, the JSON representation of the resulting FHIR resources was used as boilerplate for the mapping, i.e. the mapping file matches the JSON representation of the resulting FHIR resources without any data but with minor additional elements. In the mapping file we added metadata about the author, document types, to which the mapping files can be applied to and versions of the used standards. XPATH expressions were used to directly pinpoint a corresponding element in the source CDA document to an attribute in a FHIR resource. Additional mapping information to transform CDA specific values to FHIR values (e.g. gender, dosage instructions, etc.) were also available using references to existing ConceptMap resources. A mapping file was created for each document type separately. Figure 1 shows an example of the JSON mapping to transform the Austrian e-Medication Medication List to a patient and the various Medication FHIR resources.

```
1. {  "CDA2FHIR_oid" : "1.2.40.0.34.11.8.3",
2.    "CDA2FHIR_label" : "Document-level template of a Medication List
           document within the Austrian e-Medication projectrn",
3.    "FHIR_version" : "ca.uhn.fhir.model.dstu2.resource",
4.    ...
5.    "resources" :
6.    [...{
7.      "cda-path" : "/ClinicalDocument/recordTarget",
8.      "resourceType" : "Patient",
9.      "text" : {...},
10.     "gender" : {
11.       "cda-value" :
              "./patientRole/patient/administrativeGenderCode/@code",
12.       "cda-mapping" : {
               "http://spark.furore.com/fhir/ConceptMap/
                v3-administrative-gender" },
13.    },
14.    ...
15.   },{
16.    "cda-path" :
           "//entry[//manufacturedProduct[manufacturedMaterial/
           templateId/@root='1.2.40.0.34.11.2.3.4']]",
17.    "resourceType" : "Medication",
18.    "code" : {
19.     "coding" : [{
20.       "system" : "system test",
21.       "code" : {
22.        "cda-value" : "//manufacturedMaterial/code/@code"
23.       },
24.       "display" : {"cda-value":
             "//manufacturedMaterial/code/@displayName"}
25.   ... }]}
```

Figure 1: Example JSON mapping of Austrian e-Medication Medication List. Elements added for mapping are printed in bold.

In the metadata part of the JSON mapping the unique ID (line 1) and a human readable description (line 2) matching the CDA document type described in an implementation guide are referenced. Additionally the FHIR version used (line 3) in the mapping as well as information about the author and the version of the mapping file and general comments are located there.

Since a single CDA document can be decomposed into various FHIR resources, the metadata part includes an Object “resources” (line 5) containing an Array with the specific mappings for each FHIR resource that represents a target of the mapped document type (the mapping for the first resource starts on line 7, for the second on line 19).

Each mapping section of a FHIR resource includes an object “cda-path” (line 7 and line 16) with a String containing the XPATH to the specific XML subtree in the CDA document corresponding to the FHIR resource. A “cda-path” always indicates that the XPATH returns XML nodes. A specific value is mapped using an object “cda-value” (e.g. line 11 or 22) and the corresponding XPATH relative to the XPATH of the corresponding resource. In our example the XPATH in line 11 is applied to the XML nodes returned from XPATH in line 7. If the returned value needs transformation, a “cda-mapping” JSON object (see line 12) can be added. Besides mapped values with the object “cda-value” also fixed values “String”, “Boolean”, “Number” can be added (e.g. line 8) or prefixes and suffixes for the values (e.g ‘urn:oid’) can be specified. The date and timestamp conversions between CDA and FHIR is hardcoded in the parser and no mapping is required.

In the JSON mapping the resources have to be in chronological order. If a patient is referenced for example in the Medication resource, the Patient resource has to be defined before the Medication resource in the mapping file.

3. Results

In order to validate the proposed method to transform CDA documents to FHIR resources using a JSON mapping we created a proof-of-concept implementation using Java, the HAPI-FHIR library [15] and Java reflections. HAPI-FHIR is an open-source implementation of the FHIR specification in Java. Our prototype transforms ELGA e-Medication CDA documents into FHIR resources using the proposed JSON mapping.

The JSON mapping file is parsed using JSON.simple [16], a simple Java toolkit for JSON. FHIR classes from the HAPI-FHIR library are initiated based on the names in the mapping file using Java reflections. To set the fields of the instantiated FHIR classes the suitable setter functions are searched (i.e. *OBJECT.getMethods()*) and also called using reflections. If objects in the JSON mapping do not correspond to the FHIR specification, they are part of the mapping and are handled as described above.

The ID of a FHIR resource is the unique URL created by a FHIR server once the resource is sent to the server. Unless a created FHIR resource is immediately sent to the server, the URL of the newly created FHIR resource is not known. To ensure valid states during the transformation of CDA documents FHIR resources are only uploaded to a server once the whole document has been transformed successfully. Hence a temporary ID for each FHIR resource is created and used to cross-reference the various resources created form the same CDA document.

The resulting Java FHIR objects are serialized as FHIR bundle in JSON format. Using the HAPI-FHIR validator the resulting bundle is validated. We did not implement a FHIR server ourselves, since various open-source implementations of FHIR compliant servers are available online [17].

4. Discussion

In this work we presented a proof-of-concept mapping mechanism from HL7 CDA to FHIR loosely coupled to FHIR resources. FHIR profiles have a similar aim as mappings; they constrain FHIR resources whereas mappings describe how to initialize FHIR resources. For our approach to be applied in a productive setting, FHIR profiles should be more closely incorporated and used by the mapping mechanism. We are currently working on a FHIR profile for the ELGA e-Medication. Based on this profile we aim to analyze how the JSON mapping and future ELGA profiles can complement each other (e.g. validate transformation result with profile). By using a JSON mapping our work represents an initial design proposal to incorporate mappings natively into FHIR. We plan to further close the gap between our mapping and the FHIR specification. Our insights gained from the bottom-up approach may then be used as a starting point for the development of a FHIR resource for the mapping.

Our approach was tested using FHIR DSTU 2 and ELGA e-Medication implementation guide version 2.06.1. The mapping was specifically fine-tuned to these specifications. If the FHIR specification changes or the ELGA implementation guides are updated, our mapping has to be updated as well. Using the CDA2FHIR_oid and the FHIR_version (see figure 1, line 1 and 3 respectively) the eligible mapping files need to be selected.

Using Java reflections it was easy to reuse the HAPI-FHIR and create a parser. This ease of creation using reflections comes with the price of lower performance compared to other FHIR parsers. In our use case the performance was no problem. Our initial versions of the JSON mapping did not correspond as closely to the FHIR standard and hence our own parser was developed. For future implementations the adaptation of existing FHIR parsers should be considered.

Various approaches to transform HL7 v2 Messages or CDA documents to FHIR resources exist. In [18, 19] HL7 v2 messages are converted into FHIR resources. In the first approach the created Resources are immediately uploaded to the server and no temporary IDs are used. In the second approach a message bundle with temporary IDs similar to our approach is used to serialize the result. The uploading of the bundle to a FHIR server is done by a proprietary FHIR driver developed using HAPI-FHIR. The driver checks if the resource with the temporary ID already exists on the server. If it exists and was authored by the same source, the resource is purged and updated with the new resource. If the resource does not yet exist, a new resource is created. In contrast to [19], we do not check if the resource already exists, we currently only upload the resource.

As part of the Argonaut Project [20] all parts of the CCDA are mapped to FHIR resources and presented as CCDA profile for FHIR. We used their mapping as a starting point to create our own mapping.

In [21] the "CDA to FHIR Transformer" is presented that allows transforming of CDA documents to FHIR resources and vice versa. Unfortunately implementation details were not published. In [22] the structural definitions of a FHIR resource are described using Archetypes. Archetypes enable the authors to use their Archetype based tool to map CDA documents described by Archetypes to FHIR resources, which results in an XQuery containing all the mappings and transformation instructions. In [23] CDA documents are transformed into FHIR resources using XSLT scripts.

Using JSON to describe the mapping between FHIR and legacy data offers the following benefits compared to the other approaches mentioned earlier: XSLT and XQuery are well established standards and are predestined to be used for transformations of XML documents. Yet, whereas XSLT and XQuery are specific implementations of a transformation, our JSON mapping does not predetermine how the actual transformation is performed. The JSON mapping can be used as a starting point to automatically create the needed XSLT script or, as in our case, it could be used from within a programming language like JAVA to perform the transformation.

For legacy reasons CDA documents will stay the preferred way to archive ELGA health data in Austria. In order to reduce information overload and facilitate the access to CDA documents the FHIR API could offer a standardized way to query data at a fine granular level not excluding mobile devices. Using FHIR to access CDA documents opens a plethora of opportunities to use existing tools in the CDA world and could help to increase the value of ELGA in Austria.

Our current mapping file covers the Composition, Patient, Practitioner, Medication, MedicationDispense and the MedicationOrder resources. We are currently refining the JSON mapping to be itself a valid FHIR instance and are creating mappings for the Organization, Location, Encounter and Condition resources also needed to fully cover the ELGA e-Medication document type. Further mappings for the other ELGA document types are planned.

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References

[1] Herbek S, Eisl HA, Hurch M, Schator A, Sabutsch S, Rauchegger G, et al. The Electronic Health Record in Austria: a strong network between health care and patients. Eur Surg. 2012;44(3):155-63.
[2] Dolin RH, Alschuler L, Boyer S, Beebe C, Beilen FM, Biron PV, et al. HL7 Clinical Document Architecture, Release 2. Journal of the American Medical Informatics Association. 2006;13(1):30-9.
[3] Integrating the Healthcare Enterprise (IHE). IHE IT Infrastructure (ITI) Technical Framework Revision 9.0, 2012 Mai 2013 [21.1.2016]. Available from: http://www.ihe.net/technical_framework/index.cfm#IT.
[4] IBM Österreich GmbH. Machbarkeitsstudie ELGA. Bundesministerium für Gesundheit und Frauen Familie und Jugend, 2007, Mai 2013.
[5] Boone KW. Where in the World is XDS Mai 2013. Available from: http://motorcycleguy.blogspot.co.at/2010/01/where-in-world-is-xds.html.
[6] Duftschmid G, Rinner C, Kohler M, Huebner-Bloder G, Saboor S, Ammenwerth E. The EHR-ARCHE project: satisfying clinical information needs in a Shared Electronic Health Record system based on IHE XDS and Archetypes. International journal of medical informatics. 2013;82(12):1195-207.
[7] comScore. The U.S. Mobile App Report 2014 [21.1.2016]. Available from: http://www.comscore.com/USMobileAppReport.
[8] Health Level Seven International. Introducing HL7 FHIR 2012 [21.1.2016]. Available from: http://www.hl7.org/implement/standards/fhir/summary.html.
[9] Fielding RT. Architectural styles and the design of network-based software architectures: University of California, Irvine; 2000.
[10] Cerner Corporation. Cerner Launches Developer Experience For SMART on FHIR Applications 2016 [2.3.2016]. Available from: http://www.cerner.com/Cerner_Launches_Developer_Experience_for_SMART_on_FHIR_Applications/.
[11] Mandel JC, Kreda DA, Mandl KD, Kohane IS, Ramoni RB. SMART on FHIR: a standards-based, interoperable apps platform for electronic health records. Journal of the American Medical Informatics Association : JAMIA. 2016.
[12] Wagholikar K. Read only SMART-FHIR façade for i2b2, AID WG session at the HL7 Working Group Meeting held in Atlanta 2015 [21.1.2016]. Available from: http://www.hl7.org/documentcenter/public/wg/java/20151004_Kavi_i2b2-fhir-smart-hl7-10-15.pdf.
[13] Kasthurirathne SN, Mamlin B, Kumara H, Grieve G, Biondich P. Enabling Better Interoperability for HealthCare: Lessons in Developing a Standards Based Application Programing Interface for Electronic Medical Record Systems. Journal of medical systems. 2015;39(11):182.
[14] Integrating the Healthcare Enterprise. Mobile access to Health Documents (MHD) 2014 [21.1.2016]. Available from: http://wiki.ihe.net/index.php?title=Mobile_access_to_Health_Documents_(MHD).
[15] Agnew J. HAPI-FHIR library 1.2 2016 [21.1.2016]. Available from: http://jamesagnew.github.io/hapi-fhir/.
[16] Fang Y. JSON.simple - A simple Java toolkit for JSON 2014 [21.1.2016]. Available from: https://code.google.com/archive/p/json-simple/.
[17] Health Level Seven International. Publicly Available FHIR Servers for testing 2016 [20.1.2016]. Available from: http://wiki.hl7.org/index.php?title=Publicly_Available_FHIR_Servers_for_testing.
[18] Hay D. Mapping HL7 Version 2 to FHIR Messages 2014 [21.1.2016]. Available from: http://fhirblog.com/2014/10/05/mapping-hl7-version-2-to-fhir-messages/.
[19] Heckmann S, Paschke K. Cloverleaf on FHIR: HL7 V2 meets the Message Bundle, Paris, FHIR Hackathon #9, Track 2 2015 [21.1.2016]. Available from:

https://www.hl7.org/documentcenter/public_temp_1ACCEDC7-1C23-BA17-0CD561661A2C29A6/wg/java/20150510_FHIR_Hackathon_AID_Paris.pdf.
[20] Health Level Seven International. Argonaut Project 2015 [21.1.2016]. Available from: http://argonautwiki.hl7.org/.
[21] Lantana Consulting Group. CDA to FHIR Transformer 2014 [21.1.2016]. Available from: https://dev.lantanagroup.com/resources/free-tools/.
[22] Bosca D, Moner D, Maldonado JA, Robles M. Combining Archetypes with Fast Health Interoperability Resources in Future-proof Health Information Systems. Studies in health technology and informatics. 2015;210:180-4.
[23] Smits M, Kramer E, Harthoorn M, Cornet R. A comparison of two Detailed Clinical Model representations: FHIR and CDA. European Journal for Biomedical Informatics. 2015;11(2):en7–en17.