DOI: 10.20472/IAC.2019.047.012

SUELA MAXHELAKU

Computer Science Department, Faculty of Natural Sciences, University of Tirana, Albania

ALDA KIKA

Computer Science Department, Faculty of Natural Sciences, University of Tirana, Albania

IMPROVING INTEROPERABILITY IN HEALTHCARE USING HL7 FHIR

Abstract:

Data sharing within patients, hospitals and medical centers and the diversity of healthcare data still remain one of the main challenges in Albania. Exchanging health information is crucial because it can improve treatment, health care and decision-making process. FHIR (Fast Healthcare Interoperability Resources) is used as a standard for exchanging healthcare information in HL7 (Health Level 7). FHIR is based on the RESTful principles, so the resources can be accessed using HTTP and displayed in XML or JSON format. The aim of this paper is to analyse the use of FHIR standard in improving interoperability and integration of patient's data between different hospital services and radiology service in Albania.

Keywords:

HL7, FHIR, Healthcare, interoperability

JEL Classification: C80, L86, I10

Introduction

Patients in Albania get care from different hospitals, medical laboratories, medical centers and pharmacies. The information about the patients is distributed in different systems so the patient cannot see all his/her information and history. Even more, the data and the images are stored in different systems even in the same medical center. These healthcare information systems do not exchange information with each other. In Radiology having all the information about a patient is very important because it keeps track of patient's data, helps in diagnosing diseases and improves treatment.

Patient awareness and easy availability of data on the Internet allows patients to become informed decision makers when it comes even to disease management. (Semenov et al., 2018) When dealing with healthcare data, based on the severity and the application of their results, they should be provided almost in real time, without any errors, inconsistencies or misunderstandings. (Mavrogiorgou et al., 2019) Multi-site clinical healthcare organizations today, request for healthcare data to be transformed into a common format and through standardized terminologies to enable data exchange. (Kiourtis et al., 2019)

Interoperability will facilitate access to patient's records so patients, hospitals, etc. can have access and securely share medical history despite their location. Interoperability is not a communication between server and client and it is not just about accessing server resources or connectivity. HIMSS (Healthcare Information and Management Systems Society) defines the interoperability as the ability of different information systems, devices or applications, to connect, in a coordinated manner, within and across organizational boundaries to access, exchange and cooperatively use data amongst stakeholders, with the goal of optimizing the health of individuals and populations. (HIMSS, 2019) HIMSS defines four levels of health information technology interoperability:

- Foundational Interoperability which develops the building blocks of information exchange between disparate systems by establishing the inter-connectivity requirements needed for one system or application to share data with and receive data from another.
- Structural interoperability which defines the structure or format of data exchange where there is uniform movement of healthcare data from one system to another.
- "Semantic" interoperability which is the ability of two or more systems to exchange information and to interpret and use that information.
- "Organizational" interoperability which encompasses the technical components as well as clear policy, social and organizational components. These components facilitate the secure, seamless and timely communication and use of data within and between organizatios and individuals.

This paper explores HL7 and FHIR standard and examines how FHIR can be used in improving interoperability and exchanging data between different hospital services and radiology.

Related work

Several works are done using FHIR for increasing interoperability between systems and devices. Leroux, Jimenez and Lawley (2017) had a methodology in mapping clinical data from Clinical Data Interchange Standards Consortium Operational Data Model (ODM) to the Fast Healthcare Interoperability Resource (FHIR) and also proposed two FHIR-based models to capture the metadata and data from the clinical study.

Franz, Schuler and Krauss (2015) proposed an Integrated Health Monitoring System based on Continua Health Alliance using IHE (Integrated HealthCare Enterprise) and HL7. They provided interoperability between medical devices and healthcare systems.

Another example is FHIR FLI. This is an open source Personal Lifestyle Record that helps both consumers and organizations to combine and analyze lifestyle data, regardless of the source systems. Using FHIR ensures interoperability, allowing consumers to share data with service providers or research institutes and empowering organizations to share more data with customers. (Gopinathan et al, 2018, p.232)

Walinjkar and Woods (2018) implemented a HAPI FHIR application on IOT devices which could upload real-time ECG, PPG and relevant trauma information on a test FHIR server. The alerts and alarms mechanism could assist the emergency response teams at the hospitals to prepare for an emergency well in time. An analogue front-end biomedical device was used for data acquisition and signal processing and the IoT devices were networked over the wireless network to upload the events and observations to the FHIR server in real time.

Semenov and Kopanitsa (2018, p.117) implemented a clinical decision support system for patients. This system generates reports in natural language. Collecting medical data from heterogeneous data sources has been supported by semantic interoperability.

Yan, Xiao and Tian (2017) used the FHIR standard to standardize the exchange of clinical medical data, and build a data sharing platform with multi agent platform, so that the clinical medical data can be integrated by Agent for clinical decisions making.

In summary, FHIR offers many opportunities that can be used to standardize and increase interoperability in medical systems.

HL7 and FHIR

HL7 (Health Level Seven) is created in 1987 and offers a comprehensive framework and related standards for the exchange, integration, sharing, and retrieval of electronic health information that supports clinical practice and the management, delivery and evaluation of health services.

HL7 is at the intersection of healthcare, engineering, and Information Technology (IT). It covers almost all functional domains encountered in healthcare including patient management and administration, order management, and observation reporting. In order to achieve interoperability, many other standards are needed. Some are not specific to healthcare, such as the ones that

 ISBN 978-80-87927-60-1, IISES

pertain to security or to indexing. Others are specific to healthcare such as the Digital Imaging and Communication in Medicine (DICOM). (Noumeir, 2018)

Using a RESTful API eliminates the need to choose Windows or Linux line endings, or how to properly format string representations when using unusual delimiters like the pipe character (|), let alone SOAP envelopes. FHIR lowers barriers to implementation, especially for developers unfamiliar with legacy healthcare application protocols (e.g., HL72.x), due to adherence to RESTful design principles, which are ubiquitous in modern software development. This ubiquity enables high-quality REST libraries for nearly every programming language. (Hussain, Langer, & Kohli, 2018)

FHIR supports JSON and XML so they can implement in client-server architecture and client site as mobile users or web applications. Using FHIR standard with the RESTful framework offers the possibility to send the transaction to the server. As in other RESTful services, the client sends these transactions using HTTP request and the server sends HTTP response. Lee and Do (2018) describe this communication using the figure below.

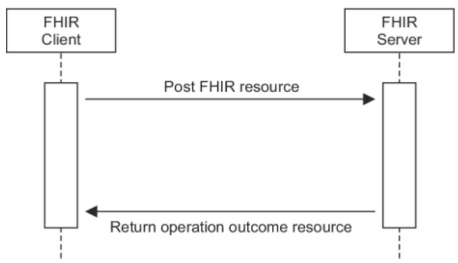

Figure 1: Communication between Client-Server (Lee and Do, 2018)

Transmitting observation data using the HL7 FHIR standard has been devised in the name of DoF (Devices on FHIR) and adopted very fast. HL7 DoF standards provide reusing of information unit known as resource, and it is relatively easy to parse DoF messages since it uses widely known XML and JSON (Lee and Do, 2018).

FHIR Structure

FHIR is built on logical related compound structures called Resources. Resources consist of small logically discrete units of exchange with defined behavior and meaning. Resources have a known identity and location identified by a Universal Resource Identifier (URI). Examples include Patient, Practitioner, Family History, Care Plan, and Allergy Intolerance. Resources are defined by using XML, JSON, or RDF. (Hammond, 2018)

The resources can be accessed using interactions. The interactions are on instance level (read, vread, update, patch, delete, history), type level (create, search, history) and the whole system (capabilities, batch/transaction, history, search).

The resources can be accessed using interactions. The interactions are on instance level (read, vread, update, patch, delete, history), type level (create, search, history) and the whole system (capabilities, batch/transaction, history, search). One clear benefit with FHIR for the field of radiology is the ability to quickly probe for relevant clinical information. With FHIR, imaging software can query clinical information mined from the EMR and integrate it with other clinical systems used by the radiologist. (Kamel and Nagy, 2018) Some of the resources used in radiology are shown in the table below. (Kamel and Nagy, 2018)

Resource	Description
Condition	A record of diagnoses, problems, and clinical conditions
DiagnosticOrder	The orders and requests placed by clinicians for imaging or laboratory studies.
DiagnosticReport	The reports for laboratory, pathology, and imaging tests.
ImagingStudy	A representation of a DICOM imaging study
Observation	A general location for lab results, vitals, and other patient measurements
Patient	The information about the patient receiving the health care service.

Table 1: FHIR Resources used in Radiology (Kamel and Nagy, 2018)

The list of all resources can be found at HL7 webpage https://www.hl7.org/fhir/resourcelist.html.

Implementation of FHIR

According to FHIR Specification (FHIR, 2018), we are using general-purpose data types: Element, Identifier, HumanName, Address to record the information for the patient. These data types are described in the UML schema below. The element is the base definition for all elements contained inside a resource. HumanName describes the name of a human with text, parts and usage information. An address may be used to convey addresses for use in delivering mail as well as for visiting locations which might not be valid for mail delivery.

ISBN 978-80-87927-60-1, IISES

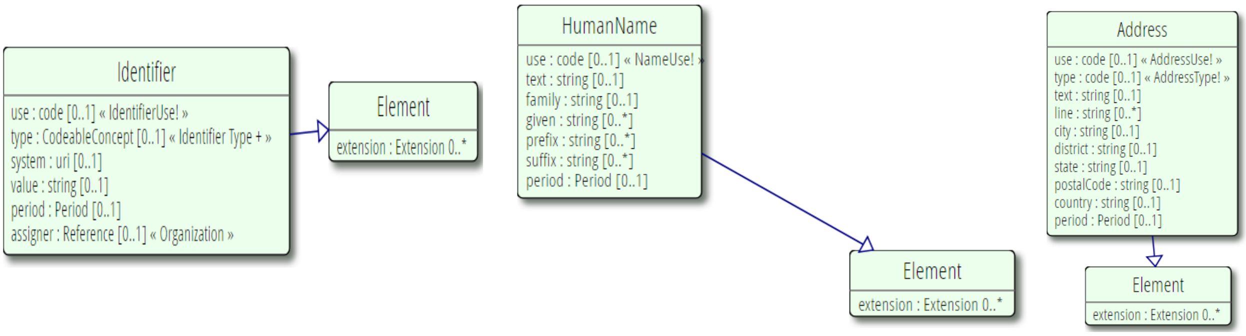

Figure 2: Examples of Data Types (FHIR, 2018)

The STU3 version is the FHIR version that was used in the presented architecture. Hl7.Fhir.STU3 is the core support library for HL7's FHIR standard (http://hl7.org/fhir). It contains the core functionality to working with RESTful FHIR servers: POCO classes for FHIR, parsing/serialization of FHIR data and a FhirClient for easy access to FHIR servers. (Nuget.org.). We have also installed Hl7.FhirPath. Hl7.FhirPath library contains a runtime environment for executing HL7 FhirPath queries and invariants. It is used by the HL7 .NET FHIR API to run validation for the HL7 FHIR object model. The version of this libraries is 1.2.1 and these were published on 16 April 2019 by Ewout Kramer and contributors.

Pyro FHIR Server for STU3 version https://stu3.test.pyrohealth.net/fhir (Millar) is the server used for testing purposes. The implementation is done with C# and .NET platform. Using FHIR to record information about the patients gives the possibility to access these data everywhere. The basic information about a patients using FHIR after executing the code will be as below in xml.

```xml
<Patient xmlns="http://hl7.org/fhir">
  <identifier>
    <value value="G35291876I" />
  </identifier>
  <name>
    <use value="official" />
    <family value="Vermoshi" />
    <given value="Maria" />
    <suffix value="PhD Candidate" />
  </name>
  <telecom>
    <system value="phone" />
    <value value="+355691234567" />
    <use value="mobile" />
  </telecom>
  <telecom>
    <system value="email" />
    <value value="mariav@gmail.com" />
  </telecom>
  <gender value="female" />
  <birthDate value="1990-03-10" />
  <address>
    <use value="home" />
    <text value="Gjergj Fishta Street" />
    <city value="Tirana" />
    <postalCode value="1001" />
    <country value="Albania" />
  </address>
</Patient>
```


Figure 3: Data stored in xml format about a patient using FHIR

Storing information using FHIR will provide different systems in Radiology with the possibility to access records about patients. In the same way we use FHIR in defining the techniques used for scanner, data regarding examination, information about the results from the scanner and diagnoses. Also using FHIR will offer the possibility to share information within DICOM attributes.

Conclusion

FHIR Uses RESTful architecture. We have presented how FHIR can be used in achieving interoperability in healthcare. Also we have identified some of the FHIR resources used in describing patients and diagnoses in Radiology. Using FHIR improves exchange of healthcare data and offers the possibility to access the data everywhere from different resources. Furthermore, it supports radiologist in monitoring patient's health status and enabling better decision-making process in diagnosis or treatments.

References

Angus, M. (2019). Pyrohealth. FHIR Server Implementation [online] Pyrohealth.net. Available at: https://pyrohealth.net/ [Accessed 1 Jan. 2019].

FHIR HL7. (2019). FHIR HL7. [online] Available at: https://www.hl7.org/fhir/ [Accessed 15 Apr. 2019].

Franz, B., Schuler, A. and Krauss, O. (2015). Applying FHIR in an Integrated Health Monitoring System. *European Journal for Biomedical Informatics*, 11(02).

Gopinathan, K., Kaloumenos, N., Ajmera, K., Matei, A., Williams, I. and Davis, A. (2018). FHIR FLI: An Open Source Platform for Storing, Sharing and Analysing Lifestyle Data. Proceedings of the 4th International Conference on Information and Communication Technologies for Ageing Well and e-Health, p. 232

Hammond W. E. (2018). 'How do you know when you have interoperability'. EJBI 2018; 14(3):13-20

HIMSS. (2019). HIMSS. [online] Available at: https://www.himss.org/ [Accessed 15 Apr. 2019].

Hussain, M. A., Langer, S. G., & Kohli, M. (2018). 'Learning HL7 FHIR Using the HAPI FHIR Server and Its Use in Medical Imaging with the SIIM Dataset'. *Journal of Digital Imaging*. doi:10.1007/s10278-018-0090-y

Kamel, P. and Nagy, P. (2018). Patient-Centered Radiology with FHIR: an Introduction to the Use of FHIR to Offer Radiology a Clinically Integrated Platform. *Journal of Digital Imaging*, 31(3), pp.327-333. https://doi.org/10.1007/s10278-018-0087-6

Kiourtis, A., Mavrogiorgou, A., Menychtas, A., Maglogiannis, I. and Kyriazis, D. (2019). Structurally Mapping Healthcare Data to HL7 FHIR through Ontology Alignment. *Journal of Medical Systems*, 43(3).

Lee, S. and Do, H. (2018). Comparison and Analysis of ISO/IEEE 11073, IHE PCD-01, and HL7 FHIR Messages for Personal Health Devices. *Healthcare Informatics Research*, 24(1), p.46.

Leroux, H., Metke-Jimenez, A., & Lawley, M. J. (2017). Towards achieving semantic interoperability of clinical study data with FHIR. *Journal of Biomedical Semantics*, 8(1):41. doi: 10.1186/s13326-017-0148-7.

Mavrogiorgou, A., Kiourtis, A., Touloupou, M., Kapassa, E. and Kyriazis, D. (2019). Internet of Medical Things (IoMT): Acquiring and Transforming Data into HL7 FHIR through 5G Network Slicing.

Noumeir, R. (2018). Active Learning of the HL7 Medical Standard. Journal of Digital Imaging, pp.1-8.

Nuget.org. (2019). NuGet Gallery | Home. [online] Available at: https://www.nuget.org [Accessed 30 Apr. 2019].

Semenov, I., Kopanitsa, G. (2018). Decision Support System based on FHIR profiles. *Studies in Health Technology and Informatics,* 249, pp 117 - 121. doi: 10.3233/978-1-61499-868-6-117

Semenov, I., Kopanitsa, G., Denisov, D., Alexandr, Y., Osenev, R. and Andreychuk, Y. (2018). Patients Decision Aid System Based on FHIR Profiles. *Journal of Medical Systems*, 42(9).

Walinjkar, A., Woods, J. (2018). FHIR Tools for Healthcare Interoperability. Biomedical Journal of Scientific & Technical Research 9(5). doi: 10.26717/BJSTR.2018.09.001863

Yan, H., Xiao, L. and Tian, J. (2017). Clinical Decision Support Based on FHIR Data Exchange Standard. Proceedings of the 2nd International Conference on Mechatronics Engineering and Information Technology (ICMEIT 2017).