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DESIGN OF TOOL-ASSISTED MESSAGE MAPPING PROCESS OF HL7

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Abstract:

In the new network-centric healthcare IT environment, standardization of information representation, organization and dissemination is the first step towards achieving semantic interoperability among heterogeneous systems. In this paper, we discuss roadblocks encountered in a real-world project to integrate two disparate healthcare systems based on HL7 v3 standards.

Introduction:

The ability of systems built upon heterogeneous information models to exchange vital clinical, financial and administrative information is pivotal to the success of healthcare organizations in providing quality services. Shifting towards an integrated healthcare environment through ventures such as Electronic Health Record (EHR) requires leveraging the new messaging and terminology standards such as Health Level 7 (HL7) and SNOMED CT1.

While the new HL7 version 3 (v3) has been hailed over its predecessors for being a "true" standard offering precision and unambiguity, the worldwide healthcare community has so far been reluctant to adopt it mainly due to its overwhelming complexity. We have experienced these real challenges in our project to integrate a Clinical Decision Support System (namely Vascular Tracker, VT) developed by the COMPETE2 group, with a Cardiac Rehab Center (CRC) in a different location based on HL7 v3 standards.

These standards are sufficiently comprehensive to cover the breadth and depth of the medical domain information. However, organization of the information models into a multi-level, domain-based hierarchy offers a challenging environment for non domain-expert IT personnel. Furthermore, creating semantic maps between legacy data and HL7 v3 messages currently requires a thorough understanding of HL7 information architecture as well as standard clinical terminology systems such as SNOMED CT [3] and LOINC3. To the best of our knowledge, there is no open-source tool to support design and implementation of HL7 v3 compliant integration. As such, message workflow design typically involves wading through pages of HL7 documentation using primitive text search tools.

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The real-world challenges that we faced during the aforementioned project served as our motivation to drive this research. Our overall goal is to develop solutions that reduce the overwhelming complexity of the HL7 v3 compliant integration projects, and consequently a wider adoption of the HL7 v3 standards.

In this paper, we propose a Tool-Assisted Message Mapping Process (TAMMP) to support the message workflow design phase of HL7 v3 compliant integration projects. We lay the foundation for a comprehensive and user-friendly tool to store, locate and explore HL7 v3 artifacts in electronic format using leading edge Semantic Web (SW) technologies [1]

HEALTH LEVEL 7 (HL7)

HL7 is a non-profit organization comprised of healthcare subject matter experts and IT professionals collaborating to develop international standards for exchange, management and integration of healthcare information in electronic format. The term HL7 also refers to the standards created by the HL7 organization.

HL7 version 2.1, originally created to support hospital workflow was improved at version 2.6 to realize interoperability between electronic Patient Administration Systems (PAS), Electronic Practice Management (EPM) systems, Laboratory Information Systems (LIS), Dietary, Pharmacy and Billing systems and Electronic Medical Record (EMR) systems. However, this standard did not adhere consistently to a data model and was text-based as opposed to XML-based. Further, the standard lacked precision and consistency seriously limiting its scalability. Thus in the late 90's there was a clear demand for a cleaner, more precise standard. HL7 v3 was envisioned and designed to overcome these limitations. HL7 v3 comprises a pair of base specifications - an object oriented information model called the Reference Information Model (RIM) and a set of vocabulary domains. RIM and its derivatives describe structure of data in terms of classes, attributes, constraints and relationships whereas the vocabulary domain encapsulates domain concepts and terms. HL7 message refinement process describes how message types are derived from core RIM classes. The strategy for development of version3 messages and related information structures is based upon the consistent application of constraints to a base specification called the HL7 Reference Information Model (RIM) and HL7 Vocabulary Domains and upon the extension of those specifications to create representations constrained to address a specific health care requirement. Constraints are applied on appearance, cardinality, type and vocabulary sets of base classes and attributes in a top down manner to recursively derive progressively specialized information structures. [2]

LOINC

Logical Observation Identifiers Names and Codes (LOINC) is a database of codes representing terms used primarily in the laboratory and observation areas of healthcare. LOINC was initiated in 1994 as a voluntary effort to meet the demand for electronic movement of clinical data from laboratories that produce the data to hospitals and physician's offices. LOINC has been identified by the HL7 Standards Development Organization as a preferred code set for laboratory test names in transactions between health care facilities, laboratories, laboratory testing devices, and public health authorities. Unlike SNOMED, LOINC codes are not organized in any symmetrical or hierarchical manner, thus making the codes arbitrary. [3]

Transformation Process

This section presents a fully-automatic, domain-dependent transformation approach for HL7 messages, which implements materialization. The approach is able to automatically transform valid HL7 messages into an RDF representation. It is domain-dependent and implements a concept in-between the design space of database-centric and ontology-centric solutions. The resulting RDF graph is materialized in a dedicated RDF database system. The overall system architecture is shown in Figure 1. Here, the HL7 Transformer is registered as a receiver at the integration engine. It transforms all incoming messages into an RDF representation and incrementally maintains a definition of the resulting schema by utilizing the RDF Schema Description Vocabulary (RDF/S).

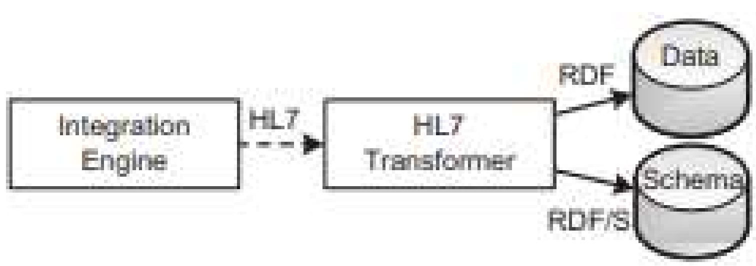


Fig 1: Architecture of the HL7 to RDF transformer

In HL7 V2, the semantics of a data item (field name) is defined implicitly by the message type, the segment and the position of a group or field within the segment. In order to create meaningful predicates in the RDF representation, a machine-readable format of the HL7 specification is required. Such a specification is provided by the HAPI project [HAP12] which implements a generic HL7 parser for Java. HAPI is utilized to parse each message and Java reflection is used to traverse the resulting object model, which provides field names. In this process, only those segments, groups and fields are transformed for which data exists within the message. Therefore, the resulting RDF representation is very compact as can be seen in Figure 2. In a real-world scenario, a large number of segments, groups and fields specified for the different message types are never used. Simply generating an RDF/S schema definition out of the HL7 specification would therefore result in a large volume of redundant metadata. In contrast, an incremental approach is implemented which always updates a global RDF/S schema description after processing a message.

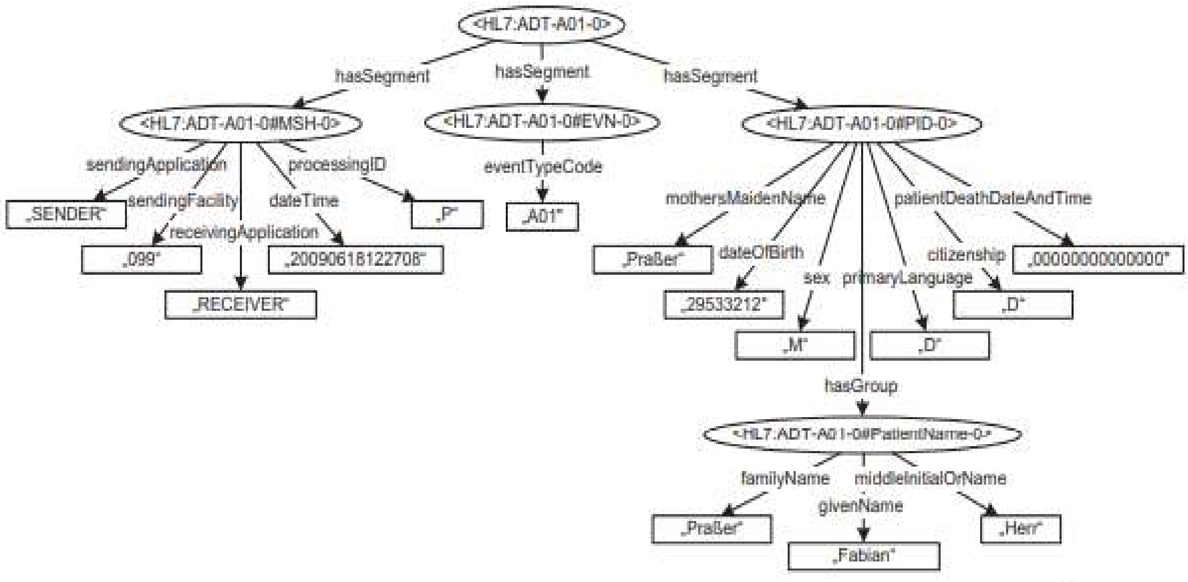


Fig 2: Excerpt of the RDF representation of the HL7 message

UML activity diagrams for the described processes are shown in Figure 3. Messages are transformed in batches. To this end, the transformation can either be executed periodically or when a predefined number of messages have been received. When a batch is processed, each message is transformed into an RDF representation and the RDF database is updated. Afterward processing a batch, the database is reorganized.

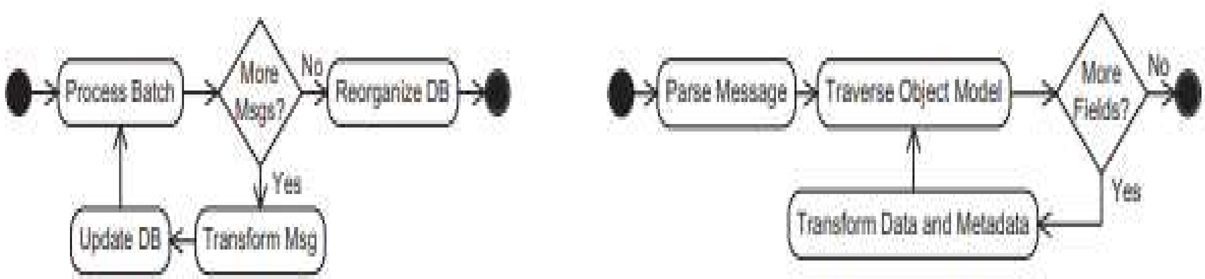
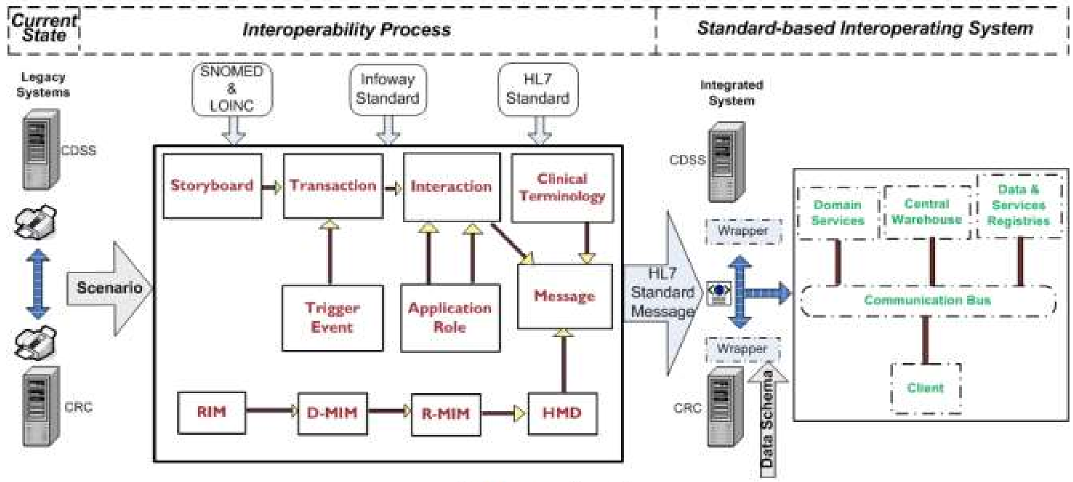


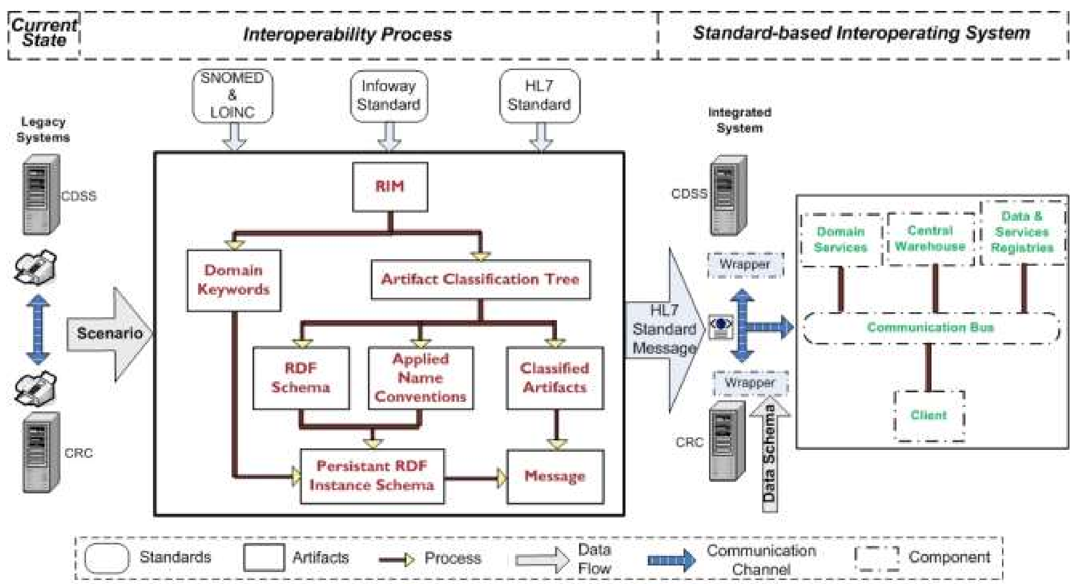
Fig 3: Processing (a) a batch of messages and (b) an individual message

When processing an individual message, it is first parsed into a Java object. The resulting object model is traversed recursively and for each method it is checked whether it returns a valid result. If it does return a primitive value, it is materialized in the resulting RDF graph by deriving a meaningful predicate from the method name. Otherwise, the returned object is traversed. In order to only retrieve data which is part of the message, we exclude some methods from this process. Identifiers for objects are generated incrementally, with identifiers for segments, groups and fields being defined relative to the current message identifier. [4]

Proposed Framework



(a) User assisted



(b) Tool assisted

Figure 4: Proposed standard-based framework for data and service interoperability in health systems. (a) user-assisted approach and (b) tool-assisted approach.

Figure 4 illustrates two proposed frameworks for user-assisted and tool-assisted scenarios to HL7 v3 message translation that allow standard-based data and service interoperability. Two legacy healthcare systems (left) are migrated into HL7-based interoperable architecture (right). Different parts of Figure 4 are described below.

Existing legacy systems

Most legacy healthcare systems communicate their data and results of services through fax machines, telephone calls, and regular mailing system, which are costly, slow, non-reliable and hard to maintain, and cause redundancies in filing information. The goal is to replace traditional communication techniques with state-of-the-art standard-based interoperable systems. Interoperability process. This part represents the steps required to migrate the data and services of the legacy systems into standard-based and interoperable systems. Two frameworks user assisted and tool assisted are illustrated in Figures 4(a) and 4(b).

Standard-based interoperating system

Once the appropriate messages are extracted, they are embedded into the wrappers in front of each of the legacy systems. The wrappers accept transfer requests from their associated legacy systems and use the mappings, generated through interoperability process and explained in the following, to transfer those using HL7 v3 messages. From architectural point of view, these wrappers are embedded into the communication bus, when employed in a typical SOA. In this architecture each legacy system would be deliberated as a client. Domain Services will include standard services in the domain. Data & Service Registries are used to register and discover different data and services. The Central Warehouse is employed to store electronic records of all patients centrally. Clients interact through communication bus. A refined architecture for the healthcare domain is proposed by Infoway called Infoway Infostructure. For details refer to the Infoway's EHRi blueprint. [5]

Conclusion

In this paper, we discussed various obstacles encountered during healthcare integration projects using HL7 v3. We have proposed a tool-assisted message workflow design process with well defined steps, aimed at reducing complexity of associated tasks.

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