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Making Messaging Standards Work: From Definition to Interoperability at Runtime

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Abstract

The synchronisation of data between healthcare IT applications is done by exchanging (in the broader sense) messages which are formatted according to one of many standards that are used in healthcare.

The most successful standard enabling such communication and co-operation for health is HL7 established in the mid-eighties starting as a communication standard within hospitals. HL7 included soon other domains such as home care, clinical studies, and prescription communication. So, HL7 supports shared care between primary, secondary and tertiary healthcare establishments.

Another very successful standard is DICOM for communicating image information among modalities and (radiology) information systems.

This review paper discusses integration issues for specification and development of messaging standards and their impact on applications.

Keywords
HL7, DICOM, IHE, systems integration, interface engine, message broker.

1. Introduction

There are generally two ways to achieve data integration in healthcare: either use one single application (and database) throughout a healthcare provider organisation (centralised approach) or synchronise the data between the healthcare IT applications by exchanging messages (decentralised approach). These messages are formatted according to one of many message standard (e.g. HL7, DICOM, xDT, EDIFACT) that are used in healthcare [1, 2, 3].

Nowadays, health systems turn towards shared care systems establishing extended communication and co-operation between healthcare establishments involved in patient's care. For exchanging patient-related, epidemiological and organisational information, syntax and semantics of data have to be agreed upon. Because platforms are often diverging in respect to data specifications, protocols, etc. of different applications established by different vendors, a common set of message specifications must be developed enabling the transmission of the required information.

The HL7 standard comprises patient administration, financial management, order and result reporting, scheduling and logistics, medical record and information management, personnel management, queries and master files. Recently, also clinical document architecture, clinical context management, Arden syntax for decision support, and lab automation have been included. The handling of claims and reimbursement provided by internationally operating vendors will be included in the next release. By that way, any administrative and medical information can be exchanged between hospitals, practices, and insurance companies as well.

At the beginning restricted to the US, the HL7 standard has been implemented in many countries all over the world. Therefore, not only regional and national, but also international requirements for communication and co-operation are fulfilled. It also facilitates newest information and communication technologies introducing a new message development framework (HL7 Development Framework - HDF) based on object oriented modelling, managed terminology, component structures as well as XML specification and exchange formats.

Currently, HL7 is promoting the integration of, and harmonisation with, other standards like DICOM enabling multimedia communication needed in the telemedicine environment. A major step forward was the arrangement to migrate the DICOM structured reporting (SR) as well as HL7 result reporting (RR) to the clinical document architecture (CDA) which incorporates aspects of both report schemas.

"Integrating the Healthcare Enterprise" (IHE) is an international initiative for combining both standards with special aspect to eliminate the weak points: It defines workflows for specific scenarios in order to improve system's interoperability [11, 15].

2. Materials and methods

Based on a structural analysis of the HL7 v2.x standard, a meta-model [4] could be established. The content extraction from documents using a style guide [7] as well as the utilisation of database techniques (like referential integrity) helps to uncover inconsistencies [4]. In newer releases of the standard, the provision of the standard's data by a database enables the standards developing organisation (SDO) to take care of inconsistency lists and helps vendors in creating interfaces.

The development of a meta-model also leads to the detection of structural insufficiencies [4]. Most remarkable was the introduction of message structure identifiers in version 2.3.1 of the HL7 standard. This improvement was the basis for introducing the XML exchange format [9, 10] as an alternative set of encoding rules [12]. This major step forward allows for using XML toolkits and techniques such as XSLT.

Introducing content management systems [8] instead of text processing systems would further improve the maintenance of standards. It would separate the content from presentation and therefore relieve the editors from the tedious task of following the style guide [7]. If this toolkit is based on Java in combination with web-based techniques, a world-wide simultaneous consistent definition of the standard has been made possible [8].

Each standard is as good as its definition. HL7 [1] aims at defining messages for healthcare in general and hospitals, insurance companies and community-based health in special. DICOM [2] is limited to communication of images between modalities and their controlling applications – most probably RIS. Both the HL7 and the DICOM standard provide means to extend their content for application specific requirements like Z-segments and Z-events, or user-defined tags as well as different transfer syntaxes [16].

Nevertheless, there are always remaining gaps which require enhancements. IHE - Integrating the Healthcare Enterprise - is an initiative [11] thereof, which defines a set of integration profiles (i.e. actors and transactions) that healthcare professionals and vendors may use in communicating requirements for the integration of products. These transactions form workflows which are based on and facilitate the use of HL7 and DICOM.

Messages may contain data in predefined fields according to the message specification as well as an additional freely definable payload. The Clinical Document Architecture (CDA) [1] is an example for the latter representing a means for structured documents which are not only used for observation reporting as it has been done in the SCIPHOX project [3, 14]. At first level, a CDA document only allows to combine free text with structured information based on XML. The new 2nd and 3rd level of CDA also supports the transport of documents as a message in combination with the appropriate message wrapper of HL7 version 3.

Anyhow, CDA is still only a "document" and therefore only part of a higher structure called electronic healthcare record (EHR). The latter provide means for integrating different documents and visualising the overall result [5]. A fundamental prerequisite thereof is the compliance with guidelines creating such documents.

Exchanging messages is the basis for communication, not counting whether different standards (HL7, DICOM) are based on different paradigms (asynchronous, synchronous). It also requires to have a common vocabulary so that the exchanged data is sharable and understood at both sides. This set of vocabulary is provided by a terminology server based on specifications like ICD, ICPM, SNOMED, and LOINC [1, 17].

The provision of the standard's meta-information in a normative form (instead of natural language) helps to specify message profiles. They are used for vendor-specific implementation purposes. They are also incorporated by interface toolkits which helps to implement interfaces directly.

Nevertheless, individual implementations suffer from different interpretations of the standard, even if a database helps to maintain a consistent set of definitions. Unfortunately, those conflicts can only be detected in site-specific implementations. Some, but not all, interfaces are implemented in a way which allows for reconfiguring the message specifications in order to alleviate differences. Message broker in general [13] (also called interface engines) are the ultimate tool to equalise differences at runtime. Certain message brokers like the IHE-Broker [15] also bridge different communication paradigms. They not only allow for one-to-one translations but also enables to adapt interaction scenarios by the help of their own database to store messages for later delivery.

3. Results

Encoding rules [1] and transfer syntaxes [2] stipulate how to encapsulate data in a message. Therefore, HL7 and DICOM have done their "homework" to specify the content and the form for transmitting data.

A consistently defined standard drastically reduces interpretation efforts and prevents from long discussions about the correct understanding. A vendor-independent, Internet-based and database-based editing toolkit not only reduces editing efforts but also guarantees consistency.

Message profiles [1] and Conformance Statements [2] reveal how implementation is done and help to check whether two applications are compliant.

4. Discussion

Localisation (country- or site-specific adaptations) of a standard may be required to solve problems which have been arisen from site-specific demands. To avoid a new dialect, the solutions (localisation) must be published for general use and taken back to the SDO for incorporation.

The increasing demand for system's integration in healthcare also requires the use of APIs for message interfaces as well as open message brokers.

Interfaces implementing message standards are a bridge from internal system's design to a common data format. Interoperability of applications requires some kind of conformity to a standard, not only when exchanging messages by specifying their contents and structure, but also their semantics, and, finally, the way they are implemented. In order to get an interoperable application, the underlying design has to follow specific guidelines implicitly embodied within the standards. Otherwise, a particular application is unable to transmit messages which are required to communicate specific data. In so far, creating new messages to overcome this problem would result in new - incompatible dialects.

The new HL7 methodology for creating V3 messages is primarily based on a single abstract Reference Information Model (RIM) and the accompanying vocabulary. The RIM is the basic source for creating specific instances (DMIMs and RMIMs) which result in concrete messages at the end of a defined generation process. All standards, esp. HL7 V3, demonstrate that interoperability can only be achieved when agreeing on the semantics of data. The lack of interoperability of current implementations and the HL7 vocabulary demonstrate that this is an essential step.

5. Conclusion

Certain improvements to a standard require fundamental, but compatible changes. Sometimes it takes a while to integrate them into the standard because human behaviour must be overcome.

An API for message interfaces - possibly based on open source - reduces development and maintenance costs and incompatibilities with other interfaces due to correct implementation at syntactical level.

A message broker facilitates the migration from point-to-point connections to multi-point connections including conversions between different physical protocols. As such, it bridges differences in implementation.

Especially HL7 is moving towards a comprehensive interoperability standard.

All efforts ultimately lead to a higher level of system integration and a better quality of care.

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