A flexible and distributed architecture for the integration, exchange, and management of clinical data

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Motivation

Health information systems play a significant role in supporting healthcare professionals and improving the quality of healthcare. Nowadays providing healthcare is increasingly changing from a sequence of isolated events towards a continuous medical process involving multi-disciplinary teams, often made up by clinicians and researchers. The need of data exchange among commercial off-the-shelf systems and open source research driven tools becomes more and more essential. It is crucial to project and develop information systems aimed at integrating, exchanging, and managing clinical data, not only inside a single organization, but also across organizations boundaries. From an academic research point of view the concrete possibility to have an easy and independent access to a huge, integrated and complete amount of clinical relevant data is a chance to improve the research prospect in the medical and biological fields. These needs can be fulfilled through the development of distributed and adaptable services that implement standard communication technologies. In particular HL7 is becoming the de-facto standard in healthcare system interoperability and communications, while open source software frameworks represent the most affordable and flexible approach in supporting software development. The resulting architecture achieves high interoperability among different applications with no constraints regarding the data sources.

Methods

We believe that the open source approach is well suited to develop affordable, interoperable and adaptable software. Such requirements are, as a matter of fact, difficult to meet in the traditional, proprietary software. Moreover, clinical data sources are numerous, strictly diversified and often semantically incompatible, so it's crucial to grant a secure access to an homogeneous dataset with no constraints. According to these needs we have implemented an open software architecture based on a middleware layer: the Mirth framework. Mirth is an open source HL7 integration engine that handles the routing, filtering and transformation of typical healthcare messages. This tool can manage a large variety of protocols, such as LLP, SMTP, generic database connectors, SOAP, FTP, Samba, and healthcare message formats, like HL7 (2.x and 3.0), X12, EDI, plain XML, and others. Mirth is well suited to integrate heterogeneous information systems, querying generic clinical data repository, transforming the information in HL7 messages, routing the data through the network, and populating an external registry through various database connectors or services. The Mirth based architecture has been easily implemented on an open source platform: Linux O.S., Apache web server and PHP script language, used to develop and run SOAP services and a prototype web application. This approach guarantees an extremely flexible architecture able to collect data from different sources. Both clinical and research requirements are fulfilled thanks to the wide and easy access to clinical data once limited only to clinicians and medical staff, but having assured the data security anyway.

Results

In addition to the functional requirements described above we found extensibility, adaptability, and data integration to be the core requirements that influenced the design of such a system architecture. The layered approach adopted facilitates a high degree of reusability and supports adaptability to new or different requirements. As a case of study, a prototype has been implemented using a web service interface together with Mirth's transformation capabilities. The prototype application is devoted to build a clinical data structure, extracting data from an Oracle database originated by a legacy laboratory application and a customized e-gov application. Data are encapsulated into HL7 messages and sent to another machine using the Samba protocol, to populate the destination registry through a SOAP service using the PHP database abstraction layer PEAR MDB2; statistical analysis are performed via a web based tool, also written in PHP. Our work shows how, using an open source solution, it is possible to interact with an existing and running commercial application to exchange information through a powerful standard format like HL7. The implemented architecture can be simply improved adding new data sources with no additional software development cost, granting interoperability and flexibility, but preserving the formal data coherence.

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