Wrapping Legacy Medical Systems for Integrated Health Network

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Abstract. Many health care facilities have information systems with support for medical record keeping, finance and workflow, however, it is widely recognized that one of the keys to cost reduction and service improvement in national health care lies in the integration of medical information system. Integrating information not only improves care delivery today, but also helps in building research bases for the enhancement of future care delivery. There exist complex, diverse and evolving systems, therefore adoption of a single client software solution or common clinical terminology is not feasible. This lack of single software solutions and common terminologies implies that integration of medical systems will need to employ and resolve the many heterogeneous systems that currently exist. In addition, a flexible infrastructure that acts as a backbone for integration of medical organizations are needed.
We present current research work aimed at realizing integration of different medical systems in a configurable network of interconnected organizations. Integration is achieved by wrapping existing systems using web service and industry standards to provide a uniform and adaptable interface with functionalities for interoperability as well as secured and controlled access among the individual systems.

1 Introduction

The influence of information technology in many areas of our lives is obvious. Communication, entertainment, business and education have all witnessed tremendous changes over the last few years due to the continuous adoption of latest innovation in technology and health care practices have not been an exception. Many health centers, practitioners and research agencies have modern systems that provide information management and communication functions for recording and retrieval of patient information, development of patient care strategies, interpretation of laboratory results and conducting case-based research [7].

Governments and organizations around the world have been involved in efforts to employ distributed technology to improve the quality of health care

services in a cost-effective way. In 2000, the Canadian government established Canada Health Infoway, an organization promoting the adoption of integrated electronic health systems across the country with a vision of a health care system supported by an *infostructure* (information structure) which provides timely and secured access to information [1]. A similar initiative is *SynEx*, a European project aimed at creating a standard for medical data exchange [4]. A key factor in achieving such global health care systems is integration of medical information systems.

The increased coverage and usage of the internet by many health care organizations, government agencies and households provides the inter-connectivity required to realize this vision of integrated health information systems for medical information exchange. An environment where "virtual medical records" are accessed from various integrated information systems distributed across regions is envisioned. Information is accessible beyond individual organizations and shared in compatible electronic formats allowing medical records to be assessed where these might have been used or created [7]. This will assist health care professionals and researchers in their activities by providing up to date information and evidenced based recommendations.
There are challenges in integration of Medical Information Systems, these include:

1. *Technical differences*
   Existing systems vary from one organization and region to another and these heterogeneous systems also evolve at varying degrees.
2. *Terminological differences*
   Similar to the technical differences, different terminologies exist among medical systems and affect the level of interoperability of the systems.

Integration solutions should address these challenges and exhibit the following features:

a.) Be flexible, maintainable and scalable.
b.) Support new and pre-existing systems.
c.) Use domain and technological standards.

2 Related Work

Health Level 7 (HL7)[2] is an ANSI-accredited Standard Developing Organization (SDO) (since 1994) whose key mission is definition of standards for exchange, management and integration of data for improved patient care as well as management and delivery of health care services. HL7 standards have increasingly been used in countries such as the United States, United Kingdom, Germany and Canada.

HL7's document-oriented information standard, called the Clinical Document Architecture (CDA) [5] is a markup mechanism that defines the structure and semantics of clinical documents (such as discharge summaries and progress

notes), it is one of the HL7 version 3 set of standards that derive their structure from the HL7's Reference Information Model (RIM) [7]. RIM is an object model designed to serve as a common reference point for consistently defining health care domain concepts and the relationships among them. It consists of classes which represent entities, actions, roles and relationships among these. *medEmed* technology is based on sharing and exchanging CDA-based documents. Domain standards like those of HL7 are necessary to realize semantic and technical interoperability between different systems.

Wrapping of legacy systems is often required to facilitate interoperability with systems using different technologies or running on different platforms. Web services are network accessible interfaces to applications, built with internet technology [8]. Standards like Hypertext Transport protocol (HTTP), Simple Object Access Protocol (SOAP) and XML are used in web service communication, providing a mechanism for applications and services to interact without the use of specific object model, unlike in middleware technologies such as CORBA and DCOM. This improves cross-platform interoperability among systems. Adoption of web services and standards such as UDDI and WSDL are potential solutions to platform dependent system integration problems.

3 Approach

A mediation technology which acts as a backbone infrastructure for integrating heterogeneous medical organizations is required to achieve the goals of an integrated health care system. A Grid paradigm that supports configuration of the network and evolution of interconnected medical organizations provides a flexible solution [3]. Each participating organization corresponds to an information service node interconnected to other organizations through components of the mediation technology.

medEmed[1] is a research initiative aimed at developing a middleware mediation technology suitable for large scale, asynchronously evolving distributed networks of interoperating organizations based on a Grid paradigm [3]. It uses active, configurable components to facilitate defined information flow processes based on integrated information systems. Information exchanged among organizations on the *medEmed* network is course-grained e.g requests for medical record, laboratory reports and population/statistical data unlike intra-organizational fine-grained data which are handled by the individual information systems.

We present a solution called the *Grid Federation Envelope*(GFE), for integrating various heterogeneous systems into health information networks, like *medEmed*. The Grid Federation Envelope (GFE) provides a web service based adapter interface for the different systems and acts as a *wrapper* with mechanisms to resolve technical and semantic heterogeneity and allowing information exchange among the various systems.

[1] *medEmed* is a project by the NetLab group in the Department of Computer Science, University of Victoria

We have designed the GFE for providing functionalities to:

a.) address semantic integration: Semantic integration and interoperability with other systems are key for exchange of information on the Grid and to facilitate this, a common model which captures concepts in the domain is required [6]; the model allows the various organizations to interpret their local data using universal concepts thus providing a basis for bridging the various systems through a set of concepts and terminology, for example the global concepts provide a means for generating information requests in a uniform way; the RIM (Section 2) from HL7 [2] is a good example of such a model in the health domain.
b.) present a federated view of multiple internal systems within an organization.
c.) accommodate evolution of wrapped system.
d.) control the information exchanged with the distributed health network.
e.) facilitate interaction through a standard format.
f.) realize an interoperable solution which is independent of underlying software system and data.

The GFE provides two levels of *integration* for the participating organizations:

1.) Global Integration: The organizations participating in the information Grid form loosely coupled collaborative systems capable of interaction, in particular, information exchange. To achieve this, each defines its level of participation in terms of data shared. Inherent heterogeneities that exist are resolved through mapping to a global conceptual model and schema transformation with specialized *medEmed* component [3].
2.) Local Federation: The existence of multiple systems in each organization could necessitate the need for internal federation for a global view to the network, if desired. The GFE allows each organization to customize its information exchange derived from its internal multiple systems.

Figure 1 shows the architecture of the GFE. The major components of this architecture are described below:

1.) Impex: The Impex component handles interactions with the various internal systems that the GFE interacts with. The Impex manages a collection of *conduits* (Conduit Layer in Figure 1), each of which provides a means to access each system. It provides the interaction to the individual systems within each organization. Conduits are an abstraction from the native formats of the underlying internal system and convert data to XML and vice versa (for input data received by the GFE in XML representation). The conduits have the necessary knowledge of the structure of their appropriate systems. We have developed conduits for systems which use MS SQL Server^{TM} and Oracle 9i^{TM}as back end data sources. With the Impex each organization decides which of its internal systems, if more than one exist, is required for participation in the integrated health network. New conduit types can be added to accommodate new systems in the organization.

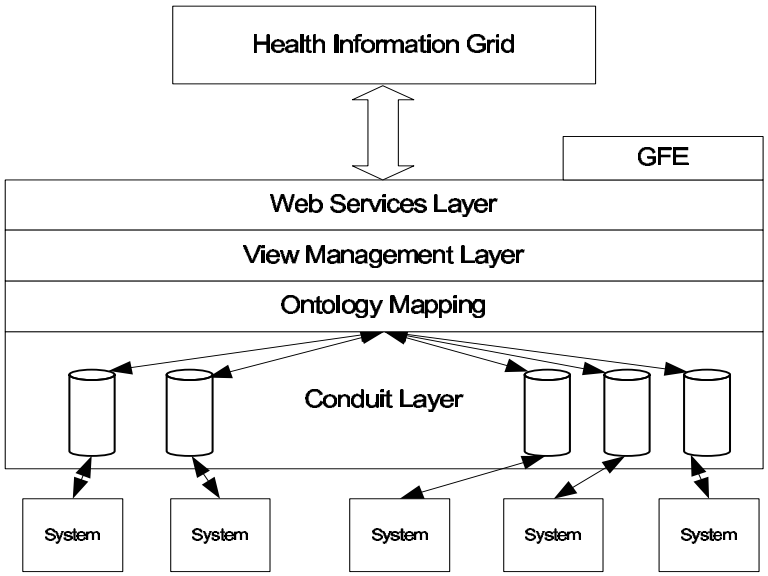

Fig. 1. GFE Architecture

2.) TokenProcessor: Semantic integration and interoperability are key for exchange of information on the Grid and to facilitate this, a common model which captures concepts in the domain is required [6]. The model provides a mechanism to bridge heterogeneous systems through universal concepts and terminology, for example, the global concepts provide a means for generating information requests in a uniform way. RIM (Section 2) from HL7 [2] is a good example of such a model in the health domain. The TokenProcessor component of the GFE provides the functionality of mapping elements to a global domain model.
The integration infrastructure of *medEmed* allows the participating organizations to define their corresponding information structures equivalent to information units exchanged on the network. The TokenProcessor is used in defining these structures, known as *Views*, and each consists of elements from the system(s) accessed through the conduit(s). The defined structures correspond to CDA based information types transmitted on the information network. The views act as links to the internal information systems. Although the current view definitions are not used for automatic translations of exchanged data to the global model in the GFE, specialized components in *medEmed* provide the feature for structural transformation to those of other wrapped systems on the network [3].
Using the *views* and mappings, the GFE limits the need for detailed knowledge of each organization's system by other participating systems in the integrated network. The *TokenProcessor* component facilitates the function-

alities of the Ontology Mapping and View Management layers shown in Figure 1.

3.) QueryPreprocessor Interaction among the wrapped systems are based on particular information types. In order for a GFE to provide response for a particular type of request, it must be able to produce information of that type. This implies defining a corresponding view with the *TokenProcessor*. The information each wrapped system exchanges in the network is specified during registration in the network. This component communicates with an internal system via a conduit and employs mapping and view definitions of the *TokenProcessor*.

The web service layer of the GFE's architecture exposes the organization's system to the integrated network.

We developed a prototype of a GUI administrative tool, *GFE Admin Tool*, to assist each participating organization in the network to configure its level of integration. A key feature is the mechanism for mapping to the common model. Figure 2 shows a screen shot of its mapping view.

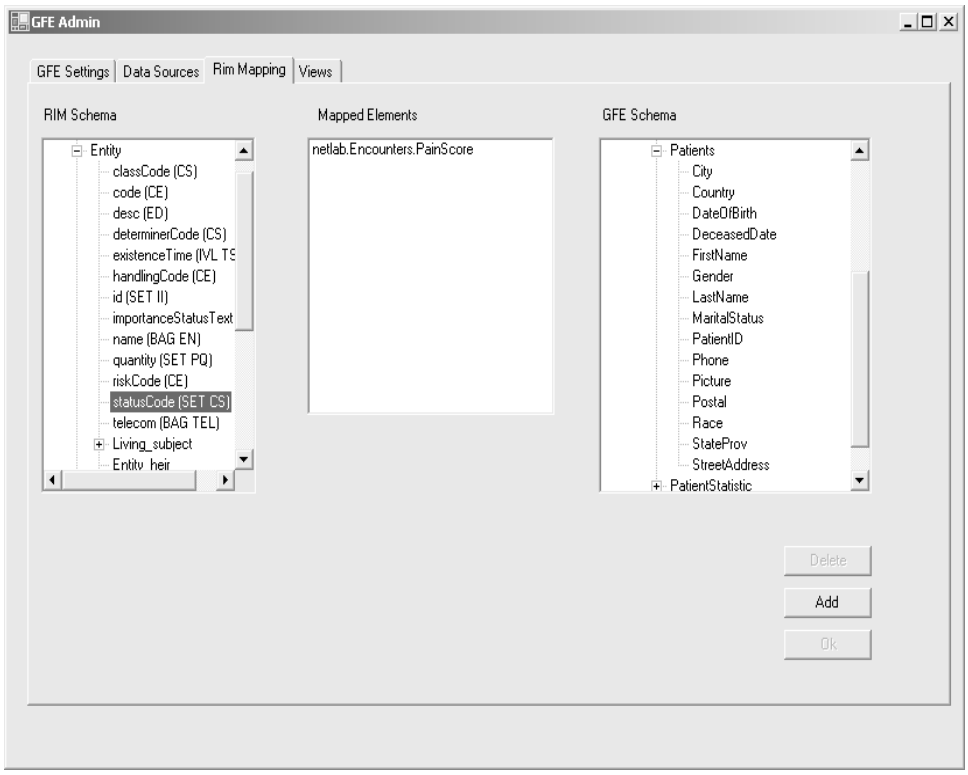

Fig. 2. Data Element Mapping in the GFE Admin Tool

The mapping involves selection of a common model element (the elements on the left of figure 2) and each of the local corresponding elements (elements listed on the right). In addition, the *GFE Admin Tool* is used for defining an organization's internal structure equivalent to the information types it can exchange as part of the integrated health system. The mappings and information unit definitions limit the need for detail knowledge of each system by other participating systems, therefore reducing coupling.

We have been evaluating our approach for legacy system integration with the wrapping mechanism by using three real example application scenarios, which we have received as in-kind contributions from our collaborators. One of these products is a leading physician information system which provides clinical records, billing and workflow features. The second one is a Clinical Vision Care system dedicated to patient eye care administration. Information exchanged between the systems include examination reports and medical histories. The third example is a collaborative study with researchers from the School of Health Information Science at the University of Victoria on integration of heterogeneous palliative hospice systems [3].

4 Conclusion

The GFE provides a means for integrating pre-existing medical systems into an global medical while divulging minimal internal structure or implementation of the participating systems. The current implementation mainly facilitates information exchange among different systems across interfaces defined with the wrapping mechanism.

Although the mapping mechanism provided by the GFE facilitates wrapping and interoperability, similar to many migration and re-engineering processes major challenges include the expertise, experience and domain knowledge required in creating the required mappings. Mere usage of an information system in each organization might not provide the knowledge sufficient for creating necessary mappings to facilitate integration. This issue is further complicated by the fact that most of the systems are commercial off-the-shelf systems (COTS). A possible way of alleviating the system knowledge required in creating these mappings will be to have in-house or vendor systems define corresponding mappings to elements in a standard global conceptual model, the GFE then automatically uses these mappings, removing the burden of defining mappings from the organizations in order to focus on specifying information exchanged as part of the network.

5 Future Work

One of the extensions we are currently investigating is workflow invocation within each of the member systems across the distributed health care systems based on external conditions and requests through the GFE interface. One use of this could be to activate processes based on information retrieved from the network,

for example, execution of a medical guideline which in turn could trigger other processes.

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