

A Lightweight Approach to Interoperable Health Information Exchange

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Abstract

The ability to electronically exchange health information among different facilities or organizations has significant potential to improve patient care and reduce the costs of that care. However, the only approaches currently known to support this exchange of information are either expensive or dependent on a centralized repository of data. We propose instead to use existing Web technology to develop a lightweight and relatively inexpensive mechanism for exchanging information that allows organizations to maintain their records independently but supports requests from other organizations for information to be fulfilled.

Introduction

In April 2004, U.S. President George W. Bush issued an executive order establishing the position of National Health Information Technology Coordinator. This position was created to support developing a nationwide interoperable health information technology (HIT) infrastructure. It is widely held that the development of HIT has the potential to greatly improve the quality of patient care, enhance the efficiency of health care professionals, and reduce the costs of health care. At the same time, the U.S. health care system has been slow in its adoption of HIT due to a number of challenges,

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including cost, resistance to change, concern of security and privacy, and unfamiliarity with the underlying technology.

An important factor in encouraging widespread adoption of HIT is the ability for providers to exchange information among varying forms of electronic health records (EHRs) and health information management systems. The U.S. government has issued directives mandating that health care providers must have systems capable of exchanging data with each other by 2014 [Charette]. However, finding a way in which the disparate systems in existence today can exchange information with each other has the potential to be both timely and costly. Most currently proposed solutions require a connection from each system to every other system and/or the use of interface engines to achieve such exchange.

As an alternative, we propose a lightweight solution for health information exchange based on Web services technology. Our solution is flexible, relatively affordable, and can operate over the commodity Internet. Our solution is also scalable to a large number of systems and is able to deal with changing communication standards and data sources.

Interoperability and Electronic Health Records

There are a number of different views as to what comprises an electronic health record. A national EHR taskforce in Australia defined the EHR as:

an electronic longitudinal collection of personal health information usually based on the individual, entered or accepted by health care providers, which can be distributed over a number of sites or aggregated at a particular source. The

information is organized primarily to support continuing, efficient, and quality health care. The record is under the control of the consumer and is stored and transmitted securely [National EHR Taskforce].

A number of EHR systems are already commercially available throughout the U.S. and other countries; however, these systems are largely based on proprietary architectures and as yet are incompatible with each other in terms of sharing or communicating information. Standards are being developed that would define a common framework for exchanging information, but as yet there is no equivalent of internetworking for health information systems. This lack of *interoperability* eliminates one of the major advantages of using EHRs, the ability to quickly and accurately transmit a given individual's information among various providers working with that individual. It also prevents the individual patient from having easy access to all of his/her health information, an idea that is gaining support as a way to provide patient-centered health care and involve the patient in the decision-making process throughout the continuum of care.

There are two basic approaches to supporting interoperability for EHR systems. The *centralized* approach is based on collecting and storing comprehensive patient data in a single repository or location. The most extreme form of this approach would be a single data repository containing the health information for every person that ever saw a practitioner. While easy to comprehend, such a system would have to be implemented at a national level (if not global); not only would this be a massive undertaking to implement and maintain, it would likely meet significant resistance on the part of practitioners and patients alike.

A more reasonable approach would be to use some kind of interface to integrate subsets of information. Here, individual service providers would maintain the details of their encounters with the patients in independent records, which would then be integrated into a comprehensive EHR. Authorized individuals (including the patient) would be able to locate and access these subsets of information through the interface and view the details of available records.

Unfortunately, in the modern health care system, there are likely to be a number of different providers involved in the care of a given patient. Depending on the complexity of the care and/or conditions involved, each of these providers may have an independent EHR for a single patient. This leads to the consideration of a *distributed* approach to the EHR, where no location is considered the “primary” repository of information. In this approach, a comprehensive record can be created only by locating the various records for a patient and integrating them at the location where the information is needed. The distributed approach has several advantages, including the ability to access the most recent entries in a patient’s health history regardless of where those entries reside and the elimination of the need for a large centralized database that would be a tempting target for unauthorized users. However, it also requires the development of both technology and standards for exchanging information among the various information repositories.

Several attempts to develop health information exchange systems have been made over the last four decades, with varying results [Charette]. For example, the Mayo Clinic took over ten years to implement an electronic solution that supports a paperless office. This system, however, is still unable to exchange information between Mayo’s facilities

in Rochester MN, Jacksonville FL, and Scottsdale AZ. The major problem in the lack of interoperability is that national standards for digitizing and interconnecting patient data have not been agreed upon. Mayo, instead of creating its own standards of interoperability and running the risk of not being able to communicate with health care providers outside of its partnerships, has chosen to wait for national standards to be set before implementing an exchange mechanism.

Such concern about being able to communicate with health care providers outside of a single enterprise or organization is a valid one. A single cost-effective solution that can exchange information among multiple providers is clearly preferable over multiple interfaces designed specifically for individual health care providers. This approach requires standardizing the communications protocols used in exchanging information would remove the need for specific interfaces, but because the standardization is focused on the communications, existing systems are not forced to conform to an internal or representational standard. Instead, internal information can be translated into the communication specification, so each participating facility can represent the information as desired.

Standardizing the communication at the network level ensures that the information can be exchanged among health care providers; however, it does not guarantee that the information exchanged between providers represents the same thing. One approach to this problem is the HL7 protocol [HL7 Organization]. This protocol standardizes messages passed back and forth between health care entities within a health care enterprise as a string that contains several fields concatenated together, separated by a pipe delimiter [Kaldoudi, Huang].

Another approach to standardization is being taken by the Healthcare Information Technology Standards panel, which recently identified an *initial* set of 90 medical standards out of an list of about 600 [Charette]. These are the technical standards for the U.S. nationwide record system. However, the fact that this is defined as an initial set of standards suggests that these standards themselves may change.

XML and Information Exchange

Even when standards are adopted, there will still be a need for an infrastructure through which standardized information can be exchanged. Interface engines have been at the heart of the exchange of medical information for many years [Cupito]. The ability to automatically convert information between differing formats through a software interface is useful for information exchange. However, these systems typically are designed for interfaces to legacy databases within an organization and not for exchanging information across organizational boundaries. Moreover, they are very expensive to purchase and maintain, which puts the technology out of reach of small health care facilities, which comprise the major of practices in the U.S.

An alternative that is less expensive, both in terms of cost and development, is the use of Extensible Markup Language (XML) to provide Web-based interfaces to information. XML has been in development since 1996. Derived from Standard Generalized Markup Language, it was originally used to describe a class of data object, as well as describe the behavior of programs. Since then, it has been found to be very useful in exchanging data. Using tags to surround a piece of data, XML documents are

able to name objects within the document. This makes an XML document readable to both the human and computer form.

An XML document can exist as a file or be transmitted electronically. To transport an XML document via a network, the Simple Object Access Protocol (SOAP) was created. The SOAP message contains three parts: an envelope, a header, and the body. The envelope is the basic container for the message. The header can contain information about routing the message, as well as any security measures that may need to be taken, while the body contains the XML message itself. SOAP messaging, which operates on the HTTP protocol, can be used to send information either in one direction, such as sending the lab results to another department/process, or in two directions, such as a remote procedure call that requests and returns data.

Several examples exist for using XML as a medium for information exchange, including genomic, clinical, and image data [Shabo, Um, Kaldoudi, Anzböck]. Recent work on an electronic patient record [Malamateniou] describes exchanging information within an organizational environment. The goal is to integrate, coordinate and authorize access to patient data based on a work flow. Information requests and results are stored in a database as an XML document. When the information is exchanged in this format, the XML document is encapsulated in a SOAP-encoded message.

Authorization to information within these XML documents is controlled at the user role level. Based on a user's role, Document Type Definitions (DTD) can specify who is permitted to view information within the XML documents. This requires prior definitions of roles within the health care system, as well defining which information each role is permitted to access.

Web Services and Information Exchange

While the use of XML and SOAP for exchanging information works well within a single enterprise or organization where the information flows are agreed upon by all of the users involved, problems arise when this approach is used to exchange information among organization that define information flows differently. XML documents as well as DTDs can be exchanged between two organizations, but it cannot be assumed that both organizations have identically defined formats and roles in their systems.

A solution to this problem can be found in the concept of *Web services* [Deitel]. Web services, first introduced by Microsoft in 2000 and now available in a variety of development platforms (including Java and .NET), provide a simple way to get information over the Internet from one platform/source to another platform/source using XML documents within SOAP messages. To allow another source to use (consume) a Web service, the producer of the service needs to provide a Web services description language (WSDL) file that describes the service. The WSDL file contains XML code to describe the procedures that are available, what parameters are expected, and what the return values will be. The WSDL file is placed on a Web server where others may view it and access it to determine the service(s) available. Software programs that can view the WSDL file over the Internet may also create procedures to send and receive the messages defined.

Web services can be used as middleware to help facilitate communication among disparate systems within a given organization. One approach to this [Anzöck] uses modeling of work flows to implement Web services within a hospital. The process starts by identifying the work flows within a hospital. In addition, the information that each

department collects is identified. Then the information that is supposed to follow each work flow path is identified.

Web services are then used to pass information from one entity to another within the hospital. For example, when a patient is first admitted, several entities are alerted to the patient's arrival. This process is considered a transaction, and therefore after the message is sent announcing the arrival of a patient, an acknowledgement or response is required for the transaction to complete. If the acknowledgement is not completed, the process must undo whatever procedures did complete.

Interoperability and Web Services

Unfortunately, this approach still does not deal with the problem of interoperability across organizational or facility borders. To address this, we propose a lightweight and relatively simple solution to this problem using Web services, SOAP, and XML. The solution is also scalable, allowing the addition of new entities to the network with minimal impact to the existing entities. This solution would allow health care providers in any location to get information about a patient on demand while supporting a distributed model of storage.

Each participating entity will be required, at a minimum, to provide two Web services. The first Web service would receive a query including a patient identifier or locator as an input from the outside world, and would return the health records stored at that facility to the requesting entity. This Web service would pool all of the data located within that entity to construct the return record in a specified format.

Additionally, each entity in the network would need to write a Web service application that would consume the other participants' search requests. This service would return the information to the requester, which then would decide what to do with the information received. However, if an additional entity is added to the exchange, including the Web services described above, the original participating entities will need to update their applications to consume the new web services provided by the new entity. Using this approach would eventually lead to every entity having to have a separate application to consume everyone else's web services.

Instead of updating all applications to consume a new Web service each time that a new entity joins in the exchanging of information, we suggest using a neutral Web service that acts as a registry of all entities wishing to exchange data. To participate in the information exchange, an entity would need to register its Web services with the neutral Web service. Then, instead of directly consuming Web services of each individual entity participating in the exchange, a participating entity would consume the neutral Web service, sending requests and information through it. A search request would send a patient locator to the neutral Web service, which would then search all of the registered entities' Web services for the relevant data and return it as a Web service to the requester. Note that the neutral service does not store the information, but rather acts something like a router to move requests and responses to the appropriate entity's interface. Figure 1 shows the architecture for this scenario.

In order to provide Web services that will receive and answer these messages, each entity will need a server capable of hosting Web services. This Web server should be able to cross the firewalls between the local EHR and the Internet in a secure,

controlled manner. This server could provide connections to the local EHR either through database drivers that enable the Web service to query the local EHR system directly, or an interface that supports the consumption of Web services internally that can return the requested information.

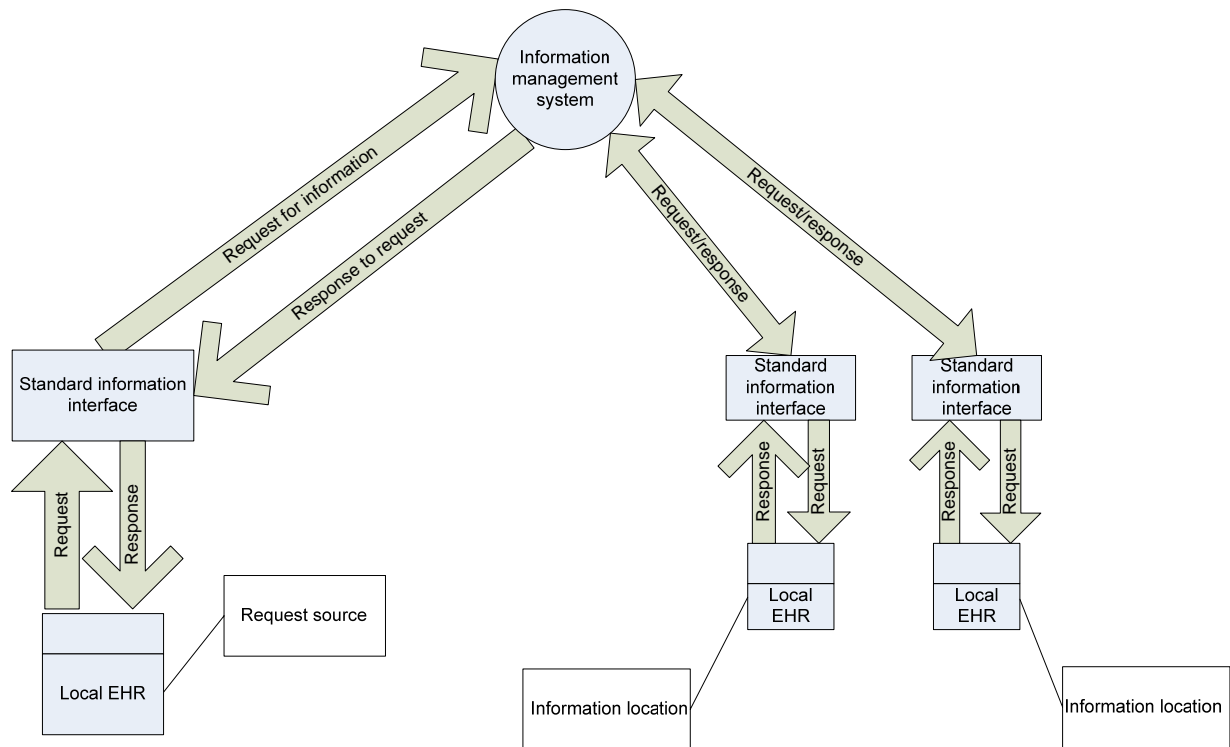


Figure 1. Interoperable exchange of health information.

Obviously, for this approach to work, a standardized set of messages will need to be defined. This could be based on HL7 or another approach. Once these standards have been determined, each participating entity in the information exchange network will be able to create a set of Web services that will accept and return messages. Note that the exchange network does not necessarily need to define the format of these messages: rather, it must standardize conventions about what information will be exchanged and what data types will be included. It is important to note that, as long as a data type is not

proprietary to a particular system, data of that type can be exchanged among different languages and operating systems easily.

Conclusion

Health care institutions have been investing in computerized systems for many years. What is different about the current environment is that the health care industry is no longer just looking at automating the administrative or back-office work within an institution. These new information systems are intended to allow communication with each other across systems and institutions for a broader array of purposes. By collecting electronic health data from multiple sources and analyzing or presenting it in usable form at the point of care or in other contexts, a health information exchange has the potential to improve the quality and safety of care delivery, enhance the development and dissemination of evidence-based protocols, or allow more effective allocation of health care resources.

The health care industry is facing many challenges in sharing information among providers. Mandates for interoperable health information exchange do not address the issues of disparate systems, incompatible data formats, and changing standards. For these reasons health care providers are in a holding pattern and are either waiting for further standardization before addressing the issue, or not even entering the EHR arena until these issues have been solved.

However, technical developments over the last decade have made it possible for disparate systems within a facility to exchange information. XML and SOAP have provided the means to exchange information among these systems. The introduction of

Web services takes advantage of these technologies to integrate these systems with a mechanism for interoperability.

Using Web services to exchange information among health care providers is a natural step forward. Web services deal well with changing standards by allowing each provider to make changes to one set of services, rather than to several different interfaces. With standards of information exchange in a state of flux, this approach allows adding or changing information within the Web services relatively easy.

Adding a new participant to the collaboration would have a minimum impact to the whole system in this approach. At a minimum, only the neutral Web service will need to be changed to consume the new Web service. It may even be possible to create a dynamic linkage to new services, so that only a registration function would be needed to maintain the neutral service.

To test this approach, we are creating a pilot version of an interoperable health information exchange system. We plan on finding two or three health care providers who will allow us to duplicate their EHR records. We will then create the neutral Web service as well as the Web services necessary to exchange information among the providers and the neutral Web service. We will report on our progress at the conference.

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