Service-Oriented Architecture:

An Approach to Facilitate Interoperability of Health Care Systems

Northwestern University

January 25, 2009

Peris Brodsky

Mitchell Carneol

Melody Dungee

Erin Kristine Laney

Shujen Yeh

Introduction

Health care practices and medical treatments are constantly evolving to meet the demands of diverse populations with complex disease processes. The Joint Commission for Accreditation of Health Care Organizations (JACHO) and other government regulatory agencies demand compliance to national patient safety standards and protocols. In addition, the current economy has forced health care and government leaders to take more fiscal accountability to maximize resources. Health care organizations can strategically meet these requirements by establishing interoperability as a best practice to improve patient outcomes. A service-oriented approach to computer system architecture can facilitate the interoperability of health care systems.

Service-Oriented Architecture Defined

Service-oriented architecture (SOA) is a strategy for organizing and managing computer software systems at the enterprise level. SOA enables an enterprise to select "best-of-breed" application functions without incurring the costs of integrating them that would otherwise result. With the standardization of behavior that SOA implies, applications acquired from different vendors and managed by different organizations can be plugged into an orchestra of enterprise computing.

SOA adopts two key architectural principles of individual system development and applies them to the entire spectrum of systems that an organization uses, including those controlled by business partners. As such, SOA does not prescribe or reference any particular technology platform or implementation because the variety of platforms within most organizations is unlimited.

The first key principle is *modularity.* This is the idea that a system should be decomposed into separate modules, each having a distinct, well-defined responsibility. Modularity encourages software *reuse* to eliminate the redundant work of building and maintaining replicated functions. (15)

The second key principle is *abstraction*. A module X that uses the services of another module Y does so in an abstract way that avoids creating a specific dependency on Y. This is achieved by separating interfaces from implementation. Module X is designed to use a standardized (*black box*) interface that Y implements. This allows a completely different module--call it Y'--to be substituted for Y without requiring any changes to X.

The abstraction principle is vital to much of application development. For example, the Open Database Connectivity Standard (ODBC) interface was created to allow C language programs to work with different relational database products in a standard way. Before ODBC, a database application was either a Sybase application or an Oracle application for instance, and would need to be completely rewritten to work with a different database.

SOA Simply Explained

"Architecture" suggests buildings and structure: bricks, mortar, steel, glass. Software architecture is more abstract. “Software architecture is the fundamental organization of a system, embodied in its components, their relationships to each other and the environment, and the principles governing its design and evolution.” (12) One basic computer architecture may include a browser which displays information, a server which processes information and a database which stores information.

"A service-oriented architecture is essentially a collection of services. These services communicate with each other. The communication can involve either simple data passing or it could involve two or more services coordinating some activity. Some means of connecting services to each other is needed." (14) In the non-computer world, common services may include subscriptions to services such as newspapers, cell phones or cable TV.

In the healthcare industry, examples of services include lab and imaging results, pharmacy, medication management, ADT (admission, discharge, transfer) systems, medical transcription, storage of documents, and scheduling and billing services. All these services make up a Health Information System (HIS). SOA is the integration of these different service components into an architecture that promotes the efficient delivery of medical care.

Currently, many health care systems use independent vendors to provide these services in a “tightly-coupled” group of service components or modules. Tightly-coupled components are those that are dependent on each other. "If you find a loose thread in a sweater and pull on it, you might find that the whole sweater is connected and dependent on that thread. When you pull it, the whole thing unravels." (11) This is tight-coupling. Now, if that same sweater was created with loose-coupling, it would have been made with separately knit components such as sleeves, front, back and neck. Each component is then connected by a standard stitch. Now if a thread unravels, only that one component will be affected leaving the others intact. That component (sleeve) could then be replaced. This concept is the crux of understanding how SOA can lead to greater integration. If the service modules (as noted above) are loosely-coupled, with standardized interfaces, the concept of a "plug-and-play" electronic health record (EHR) can be realized.

What is meant by a standardized interface? Using the sweater analogy, assume that amongst knitters, there is an x-stitch which is considered a standard when attaching a sleeve. It is widely accepted because it is strong and durable. The x-stitch represents an interface connecting the sleeve to the body or core of the sweater. When connecting software modules to core pieces of a hospital computer system, standardized software interfaces (like the sweater x-stitch) will allow loose-coupling. This loose-coupling allows a hospital system to shop around, find and then select best-of-breed service modules that can be “plugged (stitched) in.” Advantages of this SOA model include flexibility to upgrade to new versions of software by replacing or adding modular service components to meet new business or healthcare demands.

Standards and SOA

For successful interoperation of any kind, the systems involved must be in prior agreement about the methods and meaning of their communication. SOA does not eliminate this requirement for standards. In the end, an enterprise-wide ecosystem of standardized, service-oriented applications is what affords an organization the flexibility to plug in the technology components that best-suit its business needs. But in the end, standardization may be the most difficult SOA requirement to satisfy.

At the lower end of the spectrum, many generic technology standards are already in place and in use. These are what enable the inter-networking that most systems rely on today. In support of SOA, perhaps best-known is the W3C Web of Services (WS) standard, which defines a set of technology-agnostic standards based on the eXtensible Markup Language (XML). (16) This level of standard covers service-oriented interoperation of systems from any application domain and is used in many industries. This level of standard is necessary, but not sufficient. Standards must be defined up to the application level. (7) Only then can independently-developed systems be assured that they will interoperate correctly without modification.

To this end, for clinical heath care, the Healthcare Services Specification Project (HSSP) was started in 2005. (1) HSSP is a joint effort of Health Level Seven (HL7) and the Object Management Group (OMG). (8, 5) Some of the standard specifications that HSSP has completed are:

- Entity Identification Service (EIS): a service for identifying clinical entities and their attributes, especially patients, but also clinicians and organizations.
- Retrieve, Locate, Update Service (RLUS): a service to aggregate and modify entity information that may span multiple systems in multiple health care organizations, which is essential to the creation of EHR systems.
- Decision Support Service (DSS): a service to assess known information about a patient and render decisions by applying medical system knowledge.

Case Studies

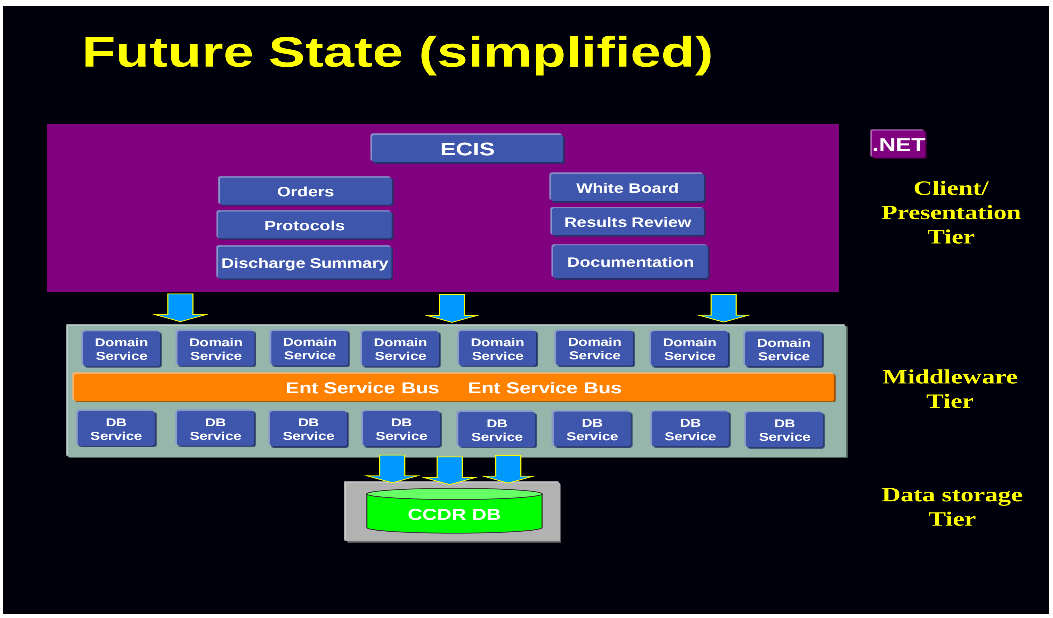
<u>Intermountain Healthcare SOA</u>

Intermountain Healthcare is nationally recognized for its ability to provide the best patient care outcomes at the lowest possible cost. (13) In order to support this mission and vision, Intermountain has taken the lead in the implementation of electronic medical records that can be accessed from all clinical settings since the 1980s. (3)

Recently, Intermountain has partnered with General Electric (GE) Healthcare to create ECIS (Enterprise Clinical Information System), a suite of clinical applications that encompasses all aspects of patient care. (3, 4) In order to make this application fully accessible, Intermountain's visionary leadership has organized the early adoption of SOA and the creation of one database to store all clinical information called the Clinical Database Repository.

Intermountain's SOA utilizes an enterprise service bus (ESB) technology, which coordinates the transfer of patient data to clinicians. (2) An ESB is one way of managing services in SOA and is built on standards to allow flexible transport of messages across an information system. (9) ESBs allow data to travel between domain services and databases through a chosen application, such as from GE or another designated vendor.

The following is a diagram by Dr. Stanley Huff, M.D., Chief Medical Informatics Officer at Intermountain Healthcare which illustrates the future infrastructure of Intermountain's clinical information systems using SOA. (4)



SOA for Clinical Decision Support in Nationwide Health Information Network (NHIN)

The Clinical Decision Support for NHIN uses an SOA approach and is known as SANDS. (6) This approach defines a standardized set of interfaces that "loosely-couples" decision support services. SANDS allows easy interchangeability of vendors. This is accomplished through the SOA principle of abstraction.

Six use cases have been developed and tested using an EHR linked to the NHIN which connects Indianapolis, Mendocino, and Massachusetts. The use cases include drug interaction checking, syndrome surveillance, diagnostic decision support, inappropriate prescribing in older adults, information delivery at the point-of-care, and a simple personal health record. (6)

The EHR prototype interfaces with the Isabel Diagnostic Decision Support System, Google Co-op (a free health search engine), UpToDate (a commercial source of evidence summaries), Lexi-Comp (a drug interaction database), and Google Earth (for reportable disease surveillance). Both UpToDate and Google Co-op were implemented for the information at the point-of-care use case, demonstrating the exchangeability of one module for another for a specific type of service. The modularity, flexibility, integration and interoperability advantages of SOA are demonstrated by these use cases. (6)

NYC Citywide Immunization Registry (CIR)

The Citywide Immunization Registry (CIR) is a centralized repository of immunization records located in New York City (NYC). Utilizing SOA and vendor specific EHRs (EPIC, Cerner, etc.), healthcare providers are able to access these records and use this information to ensure that all recommended immunizations are given. (10)

Summary

In a service-oriented architecture, "services can be shared and reused across several business processes. The result is a highly adaptive environment, with lower costs for application development, improved integration and quicker deployments." (2) The above case studies are examples of how a service-oriented architecture facilitates the interoperability and integration of health care information systems. SOAs may be implemented in several ways. Intermountain Healthcare uses EBS technology to streamline the flow of data and to provide the flexibility to replace applications as needed. This "plug-and-play" concept provides an efficient system to deal with future growth and expansion. The CIRS and NHIN examples demonstrate the incorporation of web-based SOA which is used to help disparate health care systems integrate and provide decision support at the point-of-care. Once interoperability through SOA is established, it is believed this will contribute to improved patient outcomes and lower health care costs. It is recommended that health care organizations consider using a service-oriented architecture to facilitate interoperability.

References

1. The Practical Guide to SOA in Healthcare: Healthcare Services Specification Project (web). Retrieved January, 24, 2010, from http://hssp.wikispaces.com/.
2. IBM Global Technology Services. (2008, January). *How Service-Oriented Architecture (SOA) Impacts Your IT Infrastructure: Satisfying the demands of dynamic business processes*. Message posted to https://courses.northwestern.edu/webapps/portal/frameset.jsp?tab_id=_2_1&url=%2fwebapps%2fblackboard%2fexecute%2flauncher%3ftype%3dCourse%26id%3d_248577_1%26url%3d.
3. Shortliffe, Edward H., Cimino, James J. (2006). *Biomedical Informatics: Computer Applications in Health Care and Biomedicine*, (3rd edition).
4. Impact of SOA Initiatives on Business-IT Alignment and Business Agility (web). Retrieved January 24, 2010, from http://www.omg.org/news/meetings/workshops/HC-2008/15-05_Huff.pdf.
5. Object Management Group (web). Retrieved January 24, 2010, from http://www.omg.org.
6. Wright, A., Sittig, D. F. SANDS: A Service-Oriented Architecture for Clinical Decision Support in a National Health Information Network. *Journal Biomedical Informatics, 41 (2008), 962-981.*
7. Panko, Raymond R. (2007). *Business Data Networks and Telecommunications*, (6th edition).
8. Health Level 7 (web). Retrieved January 24, 2010, from http://www.hl7.org.
9. Enterprise Service Bus (web). Retrieved January 24, 2010, from http://en/wikipedia.org/wiki/Enterprise_service_bus.
10. New York City Citywide Immunization Registry (CIR) HL7 Web Service (web). Retrieved January 24, 2010, from http://www.nyc.gov/html/doh/html/cir/.
11. Hurwitz, J., Bloor, R., Baroudi, C., Kaufman, M. (2007). *Service Oriented Architecture for Dummies*.
12. Architecture definitions (web). Retrieved January 25, 2010, from http://www.sei.edu/architecture/definitions.html.
13. Intermountain Healthcare (web). Retrieved January 24, 2010, from http://www.ihc.net.
14. SOA Defined (web). Retrieved January 24, 2010, from http://www.service-architecture.com/web-services/articles/service-oriented_architecture_soa_definition.html.
15. Service-oriented architecture (web). Retrieved January 25, 2010, from http://en.wikipedia..org/wiki/Service-oriented_architecture.
16. W3C (web). Retrieved January 25, 2010, from http://www.w3c.org.