Chapter 16
Toward Integrating Healthcare Data and Systems:
A Study of Architectural Alternatives

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ABSTRACT

The adoption of health information systems and the integration of healthcare data and systems into efficient cross-institutional collaboration workflows of stakeholders (e.g., medical providers such as physicians, hospitals, clinics, labs, etc.) is a challenging problem for the healthcare domain. This chapter studies the way that well-established software engineering concepts and architectural styles can be employed to satisfy requirements of the healthcare domain and ease health information exchange (HIE) between stakeholders. Towards this goal, this chapter proposes a hybrid HIE architecture (HHIEA) that leverages the studied styles that include service-oriented architecture, grid computing, publish/subscribe paradigm, and data warehousing to allow the health information systems of stakeholders to be integrated to facilitate collaboration among medical providers. To demonstrate the feasibility and utility of the HHIEA, a realistic regional healthcare scenario is introduced that illustrates the interactions of stakeholders across an integrated collection of health information systems.

INTRODUCTION

The healthcare domain, frequently criticized for its antiquated handling of data (e.g., by using paper-based patient registries in physician practices), has been infused with a multitude of software solutions for Health Information Exchange (HIE) that focus on the integration of patient data from multiple sources in order to improve quality of care, lower healthcare costs, and support research. Some important driving factors are programs that provide funding such as the Meaningful Use EHR Incentive Program of

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Medicare and Medicaid (CMS, 2013) or the Strategic Health IT Advanced Research Projects (SHARP, 2013) program. For example, SHARP has already spawned highly valuable platforms such as Informatics for Integrating Biology and the Bedside (i2b2, 2004) and the Substitutable Medical Apps & Reusable Technology platform (SMART, 2011). At the same time, patient involvement has been increased by initiatives such as the Blue Button (Blue Button, 2013), which allows patients simple access to their data or the data of a cared for elderly parent or child collected from participating medical providers (e.g., physicians, nurses, clinics, hospitals, image labs, pharmacies, therapists, etc.). In addition, the fitness market has exploded with a variety of fitness devices (wearable technologies) that link to mobile applications with new initiatives by the two dominant mobile computing players, Apple and Google. Apple has proposed a new HealthKit app (Apple Health App, 2015) for a dashboard to manage health and fitness data, while Google has announced its own Google Fit fitness tracker (Google Fit, 2015). Both companies are moving strongly into the smartwatch market to track motion, heart rate, blood pressure, activity, etc. In fact, Apple just announced ResearchKit (ResearchKit, 2015), an open source framework that allows researchers/developers to create apps in support of medical research; such a transformation will strongly rely on HIE in order to gather relevant data.

Despite all of the emphasis on HIE, there have been numerous problems that have been encountered during the same time span, particularly in regards to regional or statewide networks of connected healthcare stakeholders that practice HIE. Some very promising exchanges have failed (e.g., CalRHIO (Robinson, 2010) and CareSpark (Enrado, 2011)) and the progress of the work of regional health information organizations has been described as "discouraging" and "insufficient" (President's Council of Advisors on Science and Technology, 2010). However, even though the adoption of health information systems (HIS) by medical providers is starting to approach a wider acceptance in usage, the corresponding and required integration of healthcare data and systems via HIE remains a challenging problem, technologically as well as politically. On the side of technology, factors that limit adoption of HISs and HIE have been identified

(Gomes, Ziviani, Correa, Teixeira, & Moreira, 2012): a high development cost associated with HIE; a lack of agreed upon open-standardization particularly in regard to the sharing and exchange of data; a focus on brute force technology solutions rather than a healthcare process orientation that considers the needs of patients and providers and high data availability across HISs; and, the difficulty in maintaining HIE across multiple HISs that have the potential to evolve with new capabilities. On the political side, there is concern by major medical providers (e.g., hospitals in a particular region) that sharing data may lead to losing business (patients).

The healthcare domain has significant complexity and poses unique challenges that require novel approaches as well as leveraging existing solutions to have the potential to remedy the four aforementioned factors. This chapter studies established software engineering concepts, architectural alternatives, and best practices and investigates the way that they can be utilized in support of potential HIE solutions that integrate medical data and systems. We study architectural alternatives with a four step process by exploring the varied and complex requirements of the healthcare domain for supporting HIE of HISs, and matching these requirements to solutions from the software engineering domain. The first step provides an overview of software/system architectural alternatives that can be chosen for structuring an HIE system that integrates multiple HISs. The second step describes a detailed and realistic regional healthcare scenario with multiple entities that defines the scope of stakeholders that include a sole-provider practice, a community practice, local and regional hospitals, testing laboratories (blood, scanning, etc.), pharmacies, a university academic medical center, etc.; this scenario was done in collaboration with our