A PORTAL FRAMEWORK ARCHITECTURE FOR BUILDING HEALTHCARE WEB-BASED APPLICATIONS

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Abstract: Portals are Web-based applications that give users a centralized point of access for information and applications of relevance. Therefore the portal paradigm is an attractive proposition for healthcare because it offers a solution to rapidly aggregate heterogeneous applications and services while offering a high level of customization and personalization to the users, patients, care givers and IT personnel. In this paper, we explain the motivations that led us to integrate a portal framework on top of our solution stack to create healthcare solutions for our partners and customers. We describe the challenges associated with this type of infrastructure for healthcare applications including security and context management. We present concrete solutions for specific portal applications integrating EHR, PHR, care and disease management functionalities.

1 INTRODUCTION

The integration of healthcare systems and data is a major challenge. Business conditions that typically result in fragmented data stores and limited application functionality are prominent in the healthcare industry (DesRoches et al. 2008), (Ashish et al. 2009).

While other industries are advancing in SOA principles, the healthcare industry only recently has started to embrace the concept of service-oriented architecture (SOA) as a solution (Sartipi, Yarmand and Down 2007) to integrate heterogeneous and legacy systems independently from the underlying platforms or programming languages. The healthcare industry is looking for ways to process data stored in the existing silos and offer useful healthcare services to assist clinicians in making rapid and accurate decisions while helping to prevent medical errors and save costs in the process. To meet these requirements, we envision newer healthcare services for providing interactive portals for payers, providers, collaborative care and for telemonitoring.

However, because not all healthcare systems are fully modularized or offer complete external service layers or APIs, there is a need for ways to integrate functionalities higher in the software stack, closer to the presentation layer through an architecture that enables interoperability and integration (Smith 2004).

To meet these challenges, we have created a Portal framework architecture which makes the SOA concept less abstract by offering a concrete service aggregation infrastructure including integration glue like context and code mapping, transformations, master patient index, single sign on and standards based interfaces. The framework facilitates the integration of various applications, so they need not be rewritten to be able to provide services to the portal. Our portal framework is compliant with industry standards such as JSR 168, JSR 286 and WSRP (Hazra 2002).

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2 ARCHITECTURE BENEFITS

2.1 Front-end Components Aggregation

Information users often use many different systems and interfaces. The healthcare industry offers a typical example of this situation. Healthcare IT systems tend to be deployed in very specific contexts, like in departments such as labs, radiology, ER, surgery. The data generated by these systems is valuable to a range of users who play very different roles in the healthcare process. The roles these users play in their jobs are neither reflected in their systems of choice nor in a single point of access.

Therefore, the ability to create role-based front-end interfaces is valuable. Role-based concepts are included in most portal offerings and offer flexible configuration capabilities for specific targeted sets of user groups. This is especially important in the healthcare industry in the United States where the market is fragmented and requires a lot of product customization and re-branding. Aggregated in Web portals, front-end components can be built on top of existing data structures, enterprise and legacy systems as well as third-party services (Deora et al. 2006).

Though, focusing solely on market factors as drivers for front-end flexibility neglects the underlying challenge facing healthcare software developers. Not only are users confronted with multiple, siloed IT systems, they are also affected by shifting roles and a convergence of IT services made possible by growing electronic data availability. For example, physicians have traditionally focused on diagnosis and treatment, rather than prevention. But external forces like healthcare reform, Health Information Exchanges (HIE) and Pay for Performance (P4P) initiatives are shifting physicians' concerns. Fortunately, as physicians change their approach to healthcare new technologies, data and tools are emerging to aid this transition. These same tools also lead to expanded roles for other care givers and a greater opportunity for collaborative care.

This constant flux of user role definitions and changing use cases requires exceptionally agile development. Rapid prototyping and constant acceptance testing are critical to solving the business challenges of the healthcare industry. The additional development flexibility afforded by portals enables software companies to react more quickly to the market and to customers needs.

Software portal containers can help software companies break large software projects down into smaller more manageable pieces usually referred to as modules. Such modules can be visualized by portlets, which can be designed and developed separately and deployed as they are completed. As a result, vendors can more quickly develop features and functions as needed by their customers and demanded by the marketplace.

2.2 Portal Characteristics

An enterprise horizontal portal is the delivery layer for a heterogeneous environment (potentially in healthcare, the complete continuum of care). It usually includes the following features:

- **Single Point of Entry:** Portal solutions offer a unified and personalized view for various healthcare professionals (Koufi et al. 2008), and provide real-time access to a selected patients' clinical information with integrated single sign-on (SSO) authentication capabilities;
- **Permissions:** the ability for portal administrators to limit specific types of content and services to groups of users based on their respective roles and profiles;
- **Integration:** the aggregation of data and services from multiple systems including generic content, knowledge management and collaboration components into visual front-end fragments or portlets;
- **Federation:** the combination of content from various sources;
- **Enhanced User Experience:** an efficient and consistent user interface (even though the underlying services can come from multiple sources);
- **Personalization:** the ability for users to choose specific services and content tailored to their need and to customize the layout and look and feel of their presentation layer.

2.3 Benefits to the Healthcare IT Delivery Network

A portal approach can bring benefits to the whole healthcare IT delivery network:

- **Benefits to the End-users:** The portal application represents a single point of access to perform important healthcare tasks through a very convenient "dashboard" paradigm. Portal solutions also present a rich user experience by leveraging Web 2.0 technologies (Phifer, Gootzit and Valdes 2008) and specific components (e.g. wikis, blogs, message boards, social networking, maps etc). Portal customization and personalization also offers end-users a more personalized experience based on their profiles such as their role in the organization or user group and preferences (e.g. choice of layout, look and feel, medical content);

- **Benefits for the Development Team:** This includes a common architecture for the aggregation of heterogeneous components and services, a clear separation between the presentation layer and the service layer, and the fact that portlets are based on standard technologies (e.g. JSP. JSF, Spring, Hibernate, JSR 168, JSR 286, WSRP, AJAX, Java EE, or even Adobe Flex). We have also developed reusable GUI components using JSF framework and portlet templates;
- **Benefits for the Professional Service Team:** Portal technology can save substantial costs to the professional service team tasked with creating solutions. A portal approach that includes the ability to create and combine customized components that are easily customizable and re-branded for customers offers a good return on investment (ROI);
- **Reduce TCO (Total Cost of Ownership)**: For the healthcare IT departments deploying and maintaining services and applications, the ability to run multiple portal sites, each with a unique domain, on the same portal server reduces the duplication of hardware and image instances. Portlets can be deployed at run-time (hot deployment) reducing down time for the user, facilitating the maintenance of the applications and increasing the overall quality of service (QoS). In addition, specific content, branding, layout and skins can be stored and managed independently of the application in a content management system, saving costs during deployment and maintenance.

2.4 Standardization Benefits

Over the years there have been a lot of standardization efforts (HL7, ISO, Continua, HITSP, IHE) in the healthcare industry, especially in the area of interoperability. Horizontal enterprise portals can take advantage of these standards as a safe and reliable means to communicate between the different healthcare systems.

Horizontal enterprise portal servers themselves have been used successfully for more than a decade in various fields. As a result open source solutions and standards have emerged (JSR 168/286, WSRP that can be leveraged for healthcare portal applications as well (Gootzit and Valdes 2008). These standards define the basic behaviors of the container, the lifecycle management of the portlets, security, coordination between portlets, communication protocol between a portal application and remote portlets, packaging and deployment of portal applications.

2.5 Enriching the Existing Standards

JSR 168 & JSR 286 standards are useful for building relatively simple portlets. However, because today's users have come to expect responsive and fluid interactions in Web based applications, the basic call and response model of the portal server (including systematic refresh of whole Web pages) is not sufficient.

Popular Rich Internet Application (RIA) technologies include AJAX (Asynchronous JavaScript and XML), Adobe ActionScript/Flex and Microsoft Silverlight. These technologies, which are not part of the JSR portlet specifications, need to be combined with portal frameworks to create modern, interactive Graphic User Interfaces (GUI).

The solution is to build the basic functionality based on the JSR portlet standards and then extend the user interfaces using more advanced RIA technologies (Phifer, Gootzit and Valdes 208). This will allow for easy (but not seamless) portability between popular portal containers while delivering a modern user experience.

3 FRAMEWORK USE CASES

For the past couple of years we have collected requirements for Healthcare Web Applications from a number of sources: requests for information (RFI), requests for proposals (RFP) and direct discussions with our customers. In these requirements, portal architecture is mentioned more and more frequently because portals are viewed as a solution to some of the fundamental healthcare IT challenges—siloed systems as well as the convergence of healthcare services.

Table 1: Requests for proposal with portal requirements.

Request for Proposals	Date
Texas Medicaid Administrative Claiming (MAC)	2009
Kentuky Health Information Exchange	2009
Ontario Diabetes Registry	2008

In Texas, stakeholders see portals as a solution to the traditional problem of merging data from disparate systems to provide an aggregate view into a patient's status. Both Kentucky and Ontario are looking to solve similar challenges, but they are also using the unification of data as a driver to expand available healthcare IT services.

For example, in the recent Ontario Diabetes Registry RFI, the portal application includes electronic medical record (EMR) functionalities as well as other services like real-time vital signs (through device integration), e-Prescribing, doctor to patient communication, clinical guidelines, alerts and task management. The goal of this project is not only to solve the problem of decentralized data, but also to support the possibilities that IT holds for advancing healthcare delivery.

4 ARCHITECTURE DETAILS

4.1 Front-end Aggregation Layer

Our product suite was developed according to a specific set of use cases with particular user profiles. What we discovered through market research that features that were intended to be consumed by a particular user actually had relevance to other users in the care process.

To address this type of requirement, we had to integrate some of our existing products (Andry et al. 2008), (Andry et al. 2009) such as our Personal Health Record solution, our Professional Exchange Suite (PXS) in the form of our EHR (Electronic Health Record) and CDM (Care and Disease Management) solution, as well as third-party components. Some components are directly integrated at the service layer through our integration platform (IPF) that is part of our eHealth Framework (eHF).

The visual components (portlets) are integrated in a lightweight front-end layer “Fig. 2”, which in our case is a horizontal enterprise portal framework layer. Alternative architectures include widgets/ gadgets based portals (Gootzit and Valdes 2008), (Gootzit 2008) and mashup frameworks.

4.2 Context Management Layer

In addition to the front-end aggregation layer, a context management layer which uses a subset of the concepts of the HL7 Clinical Context Object Workgroup (CCOW) standard (centralized scheme, robust push-model, simplified context data representation) is used to solve user mapping and facilitate the coordination and synchronization between visual components (portlets in our case). This context management layer connects to the Web services (SOAP or RESTfull) that are exposed by the different products or in certain cases a software development kit (SDK) which encapsulates the Web services in functions (java or .NET) that are easier to use.

Table 2: Components of an EHR Light Portal.

Service/portlet	Product/provider
Patient Finder	PXS
Patient Demographic Data	PXS
Patient Medical Record	PXS
Task List	CDM
Medical observations	LS
E-prescribing	3rd party

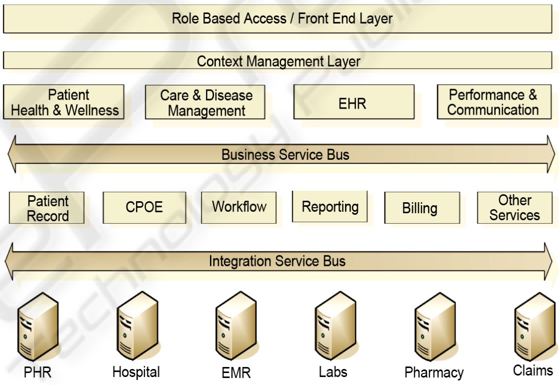

Figure 1: ICW Health Portal Framework Architecture.

4.2.1 Sessions and Contexts

A portal application like any other web application works with a session. All requests are executed in the context of such session. The session is associated with an authentication context and a lot of other information that is accumulated while processing the requests that are executed with the session. A session can be understood as a temporary storage with a well-defined life cycle. A session is ended either explicitly (log out, connection closing) or by a time-out.

In the meta-model below (Fig. 2), we describe the basic relationship between the sessions and other relevant information.

When accessing the web application for the first time there is no session established yet. The user is forced to log in (providing his identity and the credentials to prove the identity). This establishes an authentication context which is kept within a dedicated session. During the requests executed in a

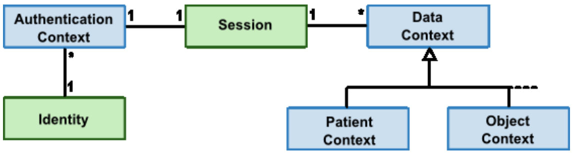

Figure 2: Meta-model connecting session and context objects.

session, information is accumulated and processed in the session. This kind of information is generalized as data context with different specializations such as context information for patient or any other healthcare domain objects.

5 DEPLOYMENT SCENARIO

5.1 Simple Portlet Integration

In the most simple deployment use case (see fig.3) the portal framework is used to create and deploy a portlet (e.g. a medicine cabinet) that is hosted in a portal container (A). The portlet uses a proxy module that has access to remote eHF-based Application (B) including the Medicine Cabinet Service Module, which exposes the required web remote interface (e.g. a RESTful web service).

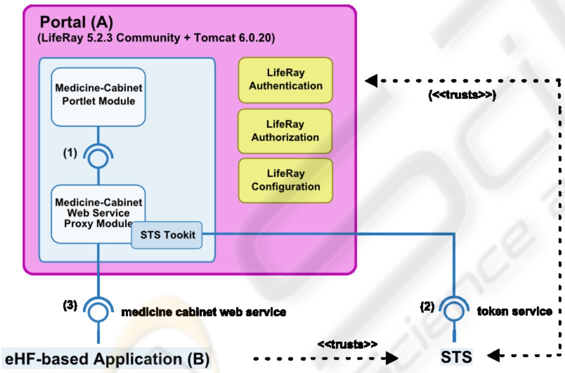
Portal (A)
(LifeRay 5.2.3 Community + Tomcat 6.0.20)
Medicine-Cabinet Portlet Module
LifeRay Authentication
LifeRay Authorization
LifeRay Configuration
(1)
Medicine-Cabinet Web Service Proxy Module
STS Tookit
(<<trusts>>)
(3)
medicine cabinet web service
(2)
token service
eHF-based Application (B)
<<trusts>>
STS

Figure 3: Portal deployment use case.

5.2 Connecting the Services

Both the portal application (A) and the remote system (B) may have their own identity management capabilities and their own credential storage. In order to integrate A and B we have implemented an extended SAML based token service. The resulting Security Token Service (STS) service includes the token service module as well as an eHF based context management module. This eHF Context Module stores the mapping information between user identifiers from A and the identities of B as described in Figure 2.

The token service toolkit provides utilities to create, renew and request tokens. In particular it is possible to request a token for B based on a token from A. The resulting token B must of course include a mapped user identifier and assertions valid for B.

5.3 More complex Scenarios

In reality, portal applications typically consist of multiple portlets that interact together. Each portlet can themselves aggregate services from various sources. This is where the portlet proxy is very handy because it can shield the presentation layer from back-end service implementation details.

The integration of a new application exposing web services (SOAP or RESTful) is made easier because eHF provides a mediation and routing platform component (IPF) based on Apache Camel that can wrap these services, operate transformations on data and expose them to the portlet proxies. In addition to this the current use of the Security Token Service for authentication can be complemented by the use of a Single Sign On (SSO) mechanism.

6 CONCLUSIONS

Our portal framework architecture provides healthcare application developers a set of open source components based on standards, tools, methods and processes to create more complex integrated and context-aware portal applications covering the full continuum of care for professional care givers and patients. Our framework offers high security, privacy, performance and scalability compliant with government regulations such as HIPAA.

In the next milestones of this project we will focus on portal usability, inter-portlet communication, quality assurance and lifecycle best practices, providing the users of our framework guidelines, blueprints and sample healthcare portlets, themes, content, as well as business perspective material (licensing, support and revenue models) related to the use of the framework.

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