Mother Theresa Group of Hospitals – HealthCare System SOA Project Plan: Approach for SOA-based Patient Care Information System

Author: Elhadi Elomda, Josh Prowant, and Murali Trikona

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Instructor: Paul I-Hai Lin, Professor

Indiana University – Purdue University Fort Wayne
M.S. in Technology – IT Advanced Computer Applications
INTRODUCTION

Problem:

- Mother Theresa Hospitals expansion to serve patients in previously inaccessible geographic areas
- Current Patient Care Information System
  - Paper-based
  - Inflexible, non-intuitive, expensive, difficult to maintain, non-scalable, non-interoperable
  - Difficult to meet quality of data standards imposed by HIPPA regulations
  - Cannot afford loss of patients and revenue attributed to medical errors
INTRODUCTION

Proposed Solution:
◆ The EJM SOA Design Team will implement the concept of Service Oriented Architecture as the base of the new Patient Care Information System
  – Provide interoperability, loose coupling, dynamic discovery, reusability, compositionality, and federation among its components.
  – Organize and utilize distributed capabilities that may be under different ownership domains.
  – Provide a uniform means to offer, discover, interact with and use capabilities to produce desired effects consistent with measurable preconditions and expectations.
  – Allow different applications to exchange data with one another as they participate in business process.
 RELATED EXPERIENCE

- Enterprise Automation System for a well-known manufacturing company:
RELATED EXPERIENCE

- SOA concepts to redesign business processes to meet challenges of manufacturing company
RELATED EXPERIENCE

- Incremental approach, focusing on implementing SOA in small steps (Lab Project Process).
RELATED EXPERIENCE

Conclusions:

- SOA concepts allowed meeting customer requirements, supporting legacy systems while adapting to growth.
  - A componentized, distributed, loosely coupled, reusable platform
  - Design allowed further automation additions and expansion
  - ROI in 1.6 years
SCOPE AND DELIVERABLES

◆ **The Project will introduce a SOA-based Patient Care Information System with the following features:**
  – Flexibility to communicate among Mother Theresa Hospitals and other healthcare providers
  – Communication with existing SAP (System Analysis and Program Development) systems for data processing
  – Security around the modules based on roles and constraints (Active Directory based authentication)
  – Automated reporting module
  – Communication between insurance carrier and hospital management system

◆ **Proposed platform for integration and interoperability:**
  – NET Framework as the key infrastructure
  – Microsoft BizTalk Server as the key integration technology utilizing HL7 and HIPPA accelerators
  – Microsoft SQL Server as the clinical data repository

◆ **Final project deliverables**
  – Design document for SOA Implementation.
  – Examination of 4 modules for potential service building identification (Phase 1)
    • Care Module (Patient Module)
    • Examination Module
    • Document/Imaging Management Module
    • Electronic Health Record (EHR) Module
  – Proposal for implementation of Patient Care Process (Examination sub-process) based on SOA technologies such as XSD, WSDL, and BPEL
  – Revisit lessons learned
CONTRAINTS AND LIMITATIONS

- Implementation limited to Microsoft platforms, although the methods discussed may still apply to various software environments.
- Does not cover patient tracking or details with RFID (Radio-Frequency Identification) software
- Does not provide CDS (Clinical Decision Support) for doctors
- The legacy EHR system will not be redesigned completely, however modifications are necessary to make it compatible and interact with other modules while implementing SOA.
HARDWARE AND SOFTWARE INFRASTRUCTURE

Logical Integration Architecture

Physical Integration Architecture

Client

Window Vista
Office InfoPath 2003X

XML

Windows Sharepoint Services
.NET Web Services

XML

BizTalk Server 2000X

XML

HL7

Patient Care System
Hospital Information System

Server

Windows Server 2008 and .NET Framework

XML

Windows Sharepoint Services
.NET Web Services

XML

BizTalk Server 2000X

XML

HL7

Patient Care System
Hospital Information System

InfoPath

Form Template

InfoPath Solution Files

Manifest

Schema

Serif

Views

Client Side Cache

Server

Windows Vista Tablet PC &
Office InfoPath 2003X

BizTalk Orchestration proxy Web
Services

Windows Sharepoint Services
Site and Lists

BizTalk Orchestration
Custom Web Services
SharePoint Event Handlers

BizTalk Server Databases

Custom database

SQL server

Windows Sharepoint Services database

Data

Data
HARDWARE REQUIREMENT

Hardware Platform

◆ 3 Dell PowerEdge M905 Servers
  – Use of four socket processors and high memory capacity (up to 192 GB 667/800 GHz DDR2 w/ 8GB DIMMS) for high performance
  – Ensured high availability due to fully redundant connectivity on all three fabrics
  – High density virtualization environments for consolidating server roles and minimizing physical inventory

◆ Tablet PCs for doctors and Network Access Controllers for VPN security
SOFTWARE REQUIREMENT

Software Tools

Software and licensing

- Microsoft Windows Server with IIS
- Microsoft Exchange Server
- Microsoft InfoPath and SharePoint
- Microsoft BizTalk Server
- Microsoft SQL Server

<table>
<thead>
<tr>
<th>InfoPath</th>
<th>SharePoint Services</th>
<th>BizTalk Server</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Streamlines the process of gathering, using and sharing information through electronic business forms.</td>
<td>- A portal server which can be customized according to the need.</td>
<td>- Serves as a business process orchestration hub.</td>
</tr>
<tr>
<td>- Design forms based on a schema, database, or a web service and publish the manifest to a portal, FTP, or shared folder.</td>
<td>- Includes security and integration capabilities.</td>
<td>- Work with adapters and accelerators for communication.</td>
</tr>
<tr>
<td>- Share the XML messages with the reference to a published URL.</td>
<td>- Acts as a library of the clinical forms in a healthcare system.</td>
<td>- E.g. EDI, Legacy Systems, HTTP, FTP, SOAP, SQL Server and HL7 Minimal Layer Protocol (MLLP). Export BPEL files.</td>
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<tr>
<td></td>
<td>- Patients and Healthcare professionals can access information through the portal</td>
<td>- Mapping tool to map XML documents</td>
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<tr>
<td></td>
<td></td>
<td>- .NET Integration</td>
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<td></td>
<td>- Pipelines to parse, serialize, decode, encode, (dis) assemble and validate incoming and outgoing messages, respectively.</td>
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<td>- BizTalk Web Services binds logical ports to Web Service definitions</td>
</tr>
</tbody>
</table>
TOTAL COST AND ROI

Cost estimations:

<table>
<thead>
<tr>
<th>COSTS</th>
<th>Pre-start</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
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</thead>
<tbody>
<tr>
<td>Software</td>
<td>500,000.00</td>
<td>50,000.00</td>
<td>50,000.00</td>
<td>50,000.00</td>
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<tr>
<td>Hardware</td>
<td>200,000.00</td>
<td>20,000.00</td>
<td>30,000.00</td>
<td>40,000.00</td>
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<tr>
<td><strong>Total Per Period</strong></td>
<td><strong>700,000.00</strong></td>
<td><strong>70,000.00</strong></td>
<td><strong>80,000.00</strong></td>
<td><strong>90,000.00</strong></td>
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</tbody>
</table>

**Infrastructure Cost**
- 22 days per month * 8 hours per Day * (10 seniors * $110.00 + 5 junior * $60.00) = 246,400.00
- 2 months of design = 492,800.00

**Design Cost**
- 22 days per month * 8 hours per Day * (5 senior * $110.00 + 10 junior * $60.00) = 202,400
- 4 months of design = 809,600.00 - Pilot Phase
- Any further development will be reduced in cost by 40%
- Development Time – 2 months Cost: $ 404,800.00
- Total Development/Implementation Cost: **$1,214,400.00**

**Development/Implementation Cost**
- Per Year: 365 days per month * 24 hours per Day * (2 seniors * $70.00 + 3 consultants * $30.00) = 1,752,000.00
- **Bonus:** 50,000 is strictly based on performance (Performance standard will be available in Contract Documents)

**Maintenance Cost**

**ROI**
- Annual Return on Investment (ROI): 61%
- Payback period (years): 1.65
- **Average yearly cost:** $1,870,000.00
### Project Timeline

<table>
<thead>
<tr>
<th>ID</th>
<th>Task Name</th>
<th>Start</th>
<th>Finish</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Development Phase</td>
<td></td>
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<td></td>
<td>SOA Implementation for</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Core</td>
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<td></td>
<td>2. EHR</td>
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<td></td>
<td>3. Examination</td>
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<td></td>
<td>4. Document Mgmt/Imaging system</td>
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<tr>
<td></td>
<td>And all related modules</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Testing/Production Release of Core Modules</td>
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<tr>
<td></td>
<td>SOA Implementation for</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. HR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. CDS</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>3. Alert System</td>
<td></td>
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<tr>
<td></td>
<td>4. Inventory system</td>
<td></td>
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<tr>
<td></td>
<td>And all related modules</td>
<td></td>
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<tr>
<td>5</td>
<td>Final Production Release</td>
<td>7/30/2009</td>
<td>8/15/2009</td>
<td>5w</td>
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</tbody>
</table>
## PROJECT ROLES AND RESPONSIBILITIES

<table>
<thead>
<tr>
<th>Role</th>
<th>Responsibilities</th>
<th>Participant(s)</th>
</tr>
</thead>
</table>
| **Project Sponsor**         | • Ultimate decision-maker and tie-breaker  
                               • Provide project oversight and guidance  
                               • Review/approve some project elements | MOTHER THERESA HOSPITAL         |
| **Steering Committee**      | • Commits department resources  
                               • Approves major funding and resources allocation  
                               • Resolves conflicts and issues  
                               • Provides direction to the Project Manager  
                               • Review project deliverables | Mr. Paul Lin & MOTHER THERESA HOSPITAL MANAGEMENT |
| **Project Manager**         | • Manages project in accordance to the project plan  
                               • Supervise vendor(s)  
                               • Provide overall project direction  
                               • Direct/lead team members toward project objectives  
                               • Handle problem resolution | Elhadi Elomda                   |
| **Project Participants**    | • Communicate project goals  
                               • Provide knowledge and recommendations  
                               • Helps identify and remove project barriers  
                               • Assure quality of products that will meet the project goals and objectives  
                               • Identify risks and issues and help in resolutions | Josh & Murali Trikona            |
| **Subject Matter Experts**  | • Lend expertise and guidance as needed | Murali Trikona, Josh and Elhadi   |
# IMPLEMENTATION RISKS

<table>
<thead>
<tr>
<th>Implementation Risks</th>
<th>Likelihood</th>
<th>Mitigation Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Business Architecture Risks</strong></td>
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</tbody>
</table>
| ✓ Improper SOA implementation due to inflexibility of other IT policies  
✓ Business process inefficiency to QoS expectation mismatch | Somewhat likely | |
| **Application Architecture Risks** | | |
| ✓ Improper identification of business services  
✓ Improper implementation of business services  
✓ Inefficient handling of error scenarios | Unlikely | SOA implementation based on well-proven and effective strategies as outlined by Microsoft. |
| **Information Architecture Risks** | | |
| ✓ Improper mapping of business object model to the physical data store | Unlikely | |
| **Technical Architecture Risks** | | |
| ✓ Improper choice of ESB solution  
✓ Improper implementation/configuration of ESB solution  
✓ Inefficient product/custom-built application integration  
✓ Risk related to inappropriate deployment strategy | Unlikely | |
RISK MANAGEMENT

- The Project Manager will ensure that team members are available as needed to complete project tasks and objectives

- The Project Plan will be executed in a timely manner (i.e., timely approval cycles and meeting when required)

- Changes to draft deliverables will be communicated effectively with respect to the project timeline to avoid delays

- Mother Theresa Hospitals will foster support to meet project goals and objectives

- Management will support the existence of a technological infrastructure that can support the new SOA implementation project for patient care information system

- The EJM team will clearly define business goals and the scope of the SOA project to avoid SOA implementation risks
SOA Planning Phase

SOA Reference Architecture

- The EJM SOA team recommends the architecture shown in Figure 6 based on the layering of the Microsoft Connected Health Framework.

- The **user layer** is responsible for providing **user support services**.

- **Middleware layer** is to exist as an enterprise resource interface to integrate legacy applications and provide data interoperability based on recognized **standards**.

Abbreviations: **HIS** stands for Hospital Information System, **RIS** stands for Radiology Information System, and **PACS** is the abbreviation for Picture Archiving and Communication System.
SOA PLANNING PHASE

**Infrastructure Standards**

The key *Infrastructure Standards* are: XML, WSDL, WS-I (Web Services Integration), UDDI (Universal Description Discovery and Integration), WS-BPEL (Web Services Business Process Execution Language), WSRP (Web Services for Remote Portlets), WS-SEC (Web Services Security), and WS-TX (Web Services Transaction).

Figure 7, Network Diagram of Hardware and Software Layout and Configuration
SOA PLANNING PHASE

◆ SOA Governance
  – Appropriate methods and processes that define the needed services, funding, ownership, design, implementation, deployment, reuse, discovery, access, monitoring, management, and retirement.
  – SOA governance life cycle
    • **Design time**: refers to the defining and controlling of enterprise services to be created in the enterprise, and the creation of policies used to direct and control the implementation of the enterprise service life cycle.
    • **Deploy time**: involves the process of testing and controlling compliance to enterprise policies in order for services to be deployed in an SOA.
    • **Run time**: refers to the process of enforcing the adherence to run-time service policies at run time
    • **Change time**: involves managing services through the cycle of change. In a service life cycle, interfaces, service Policies, and agreements may be modified many times.
SOA PLANNING PHASE

◆ SOA Security
  – Level 1
    • Firewall
  – Level 2
    • SharePoint to secure access to components, services, and databases
    • Active Directory/Windows-based authentication
      – LDAP (Lightweight Directory Access Protocol) for user credentials
    • InfoPath Form security
    • PKI (Public Key Infrastructure) mechanisms for data transfer
SOA PLANNING PHASE

◆ SoA Disaster Recovery in the event of a system failure, unplanned downtime, or natural disaster.
  – Redundant Dell Servers with virtualization capabilities to store backups of critical patient, system, and service data.
  – Offsite storage and tape backup
  – 24-7-365 professional monitoring to ensure constant uptime

◆ SoA Service Level Agreements:
  – Tools will monitor the scalability and performance as they pertain to HTTP, HTTPS, SOAP, UDDI, and WSDL to ensure meeting outlined standards in the SLA
  – Network performance and uptime guarantee
    • Network Outage: None
    • Packet Loss < 0.1%
    • Latency < 5ms
    • Jitter < 0.5ms
  – Response time guarantee
    • 24 x 7 x 365 On-site engineering
    • Emergency cases: 30 minutes
  – Application performance guarantee
    • 99.99% uptime guarantee
  – Any exceptions not within direct control of the EJM team are not covered in the SOA such as third-party hardware or software failures, outside network issues or denial of service attacks, and scheduled maintenance
Twelve services candidates have been identified:

- Rapid Response
- Care/Patient Information System
- Accounts System
- HR Management
- Document/Image Management
- Inventory Management System
- Security Management
- Electronic Health Record (EHR)
- Asset Management
- Advanced Clinical Decision Support System
- Examination
- External Data Capture System

Note: The EJM design team is only considering Implementation of the Care/Patient Information System and its related business processes for the pilot initiative.
SOA Service Modeling and Design Phase

◆ Patient Care Process (Admission)

’hui Services:
• The process may provide service functions related to patient such as:
  – Patient Registration
  – Appointment Scheduling
  – Patient Admission
  – Patient Discharge Service
  – Maintain History

’hui Process:
• The business process related to Patient Care has two types of admissions:
  • General Admission (Figure 10)
  • Emergency Admission (Figure 11)
Figure 10: Patient Care Admission Process (General)
SOA Service Modeling and Design Phase

Patient Care Process (Emergency Patient Admission)

Figure 11: Patient Care Admission Process (Emergency)
The process may provide service functions related to examinations such as:
- Care (assessment, diagnosis, discharge)
- CDS
- Examination (laboratory tests, radiology, maintain reports)
- Imaging

Figure 12: Examination Process
SOA Service Modeling and Design Phase

**Process:** Electronic Health Record (EHR)
- EHR is the GUI interface to all information needed by Nurses/Doctors/Clinical Support staff

![Diagram: Electronic Health Record Role in Architecture](image)

**Figure 13:** Electronic Health Record Role in Architecture
SOA Service Modeling and Design Phase

- Use case scenario depicting how the EHR/Care/Imaging and Examination modules interact and what each one consists of.

Figure 14: Use Case Diagram - EHR/Care/Imaging and Examination (Internal)
SOA Service Modeling and Design Phase

- The planned interacting with the final implemented Care System and how users such as patients, nurses, clinicians, clinical support, office, etc., interact with the system via the Internet.

Figure 16: Use Case Diagram – Website Login process (External)
The service inventory necessary to achieve this goal is shown in Figure 17 and the services are briefly described below. Blue circles are not implemented in this pilot initiative.

**Figure 17:** Examination Process Services
SOA Building Phase

◆ **WSDL Profiles**
  - The following table establishes the operations as defined in WSDL profiles, related to the automation of the Examination Process for each of the three services.

<table>
<thead>
<tr>
<th>WSDL</th>
<th>Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>ExaminationWSDL</td>
<td>RunLab, RunExam, AddRecord</td>
</tr>
<tr>
<td>ImagingWSDL</td>
<td>GetRecord, ManageRecord</td>
</tr>
<tr>
<td>CareWSDL</td>
<td>StartExamination, Diagnosis</td>
</tr>
</tbody>
</table>

◆ **Schema Definitions**
  - The schema definitions are modeled in accordance with existing logical data models to preserve the overall structure of data records that already exist.
  - LabTest.xsd
  - RadiologyExam.xsd
  - HealthRecord.xsd
  - Employee.xsd
  - Care.xsd
  - Given the definition of necessary WSDL profiles and XML schemas, a brief discussion of how the WSDL definitions relate to the schema definitions is provided.
Service Descriptions

Examination Service

- Examinations at Mother Theresa Hospitals are grouped into two categories: tests and exams. Each represents a type of medical examination document with different attributes and characteristics. Tests correspond to laboratory results like blood and tissue analysis, while Exams correspond to routine examinations and imaging services.
- The Examination.wsdl definition needs to expose the ability for physicians to process data associated with the two types of examinations. Separate RunLab and RunExam operations are therefore provided, each of which represent logic that accesses different databases that return different document structures.
- Almost all complex types required to define the input and output messages for the RunLab and RunExam operations are defined in the respective MedicalTest.xsd and MedicalExam.xsd schema definitions.
- The RunLab, RunExam, and AddRecord operations require the creation and distribution of patient data to electronic health records. As such, they require the employee role and ID of the medical practitioner issuing the command. The complex type for these identifiers is defined in the Employee.xsd schema.
SOA Building Phase

**Imaging Service**
- Health Records are a fundamental part of Mother Theresa Hospitals Patient Administration System and are accessed by various functions, in the case of this project, the examination services is the focus.
- The Imaging.wsdl definition provides operations for the querying and managing patient records via GetRecord and ManageRecord. It interfaces with the existing EHR System.
- The input and output messages for these operations are defined in the HealthRecord.xsd schema which represents the official document structure for electronic health records.
- Health records are considered private and secured information so the medical practitioner role and ID need to be supplied as inputs for all three operations and is defined in the Employee.xsd schema.

**Care Service**
- The Care.wsdl definition exposes a StartExamination operation that requests a date value as well as the medical practitioner role and ID for the process to begin.
- The input date value and the acknowledgment code that is output when the patient care process has been successfully initiated are defined in the Care.xsd definition. Also defined is the diagnosis information retrieved from combining examination results, EHR records, and clinical decision support (CDS) recommendations.
- The medical practitioner role and ID are defined in the Employee.xsd schema.
SOA Deployment and Management

- Patient care service components will be built in phases. During each phase, the Hospital policies determine the users that have the rights to access certain service repository. The EJM SOA team will adapt the management policies in building patient care services:
  
  - Development phase: Service component is accessible to the EJM team.
  - Pilot phase: Service component is accessible to Pilot Users.
  - Production phase: Service component is accessible to the hospital licensed users.
  - Obsolescence phase: Hospital policies restrict other users from using the service, and grandfathering those who are already clients of the service.

- SOA management should allow access control policies to be defined anywhere in the SOA federation and be usable as building blocks for more complex access control policies.
REFERENCES


Thank You!

Any questions?