A Study and Design of an Integrated Healthcare Information System Using SOA Concept and Web Services Technologies: *Case Study of EHR System in the U.S.*

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PROJECT OUTLINES

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INTRODUCTION

Problem:

- The Electronic Health Record (EHR) of an individual consists of a collection of lifetime health data in electronic format, generated during relevant interactions with the healthcare system [12].
- Patient's EHR information may be stored in such platforms as Microsoft BizTalk, IBM Websphere, Linux systems, etc.
- These systems have been responsible for introducing artificial separation between EHR lines of business applications to support rich automation functionality, as shown in Figure 1. This disintegration between the systems could worsen the EHR workflow by handicapping the accessibility of data and introduce high-risk errors into critical medical data, missed opportunities to capture revenue, and an inability to maintain customer relations and business process management.

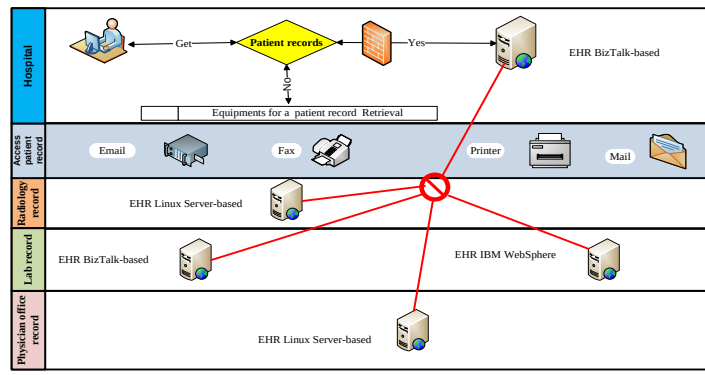

Figure 1 Disintegrated EHR Information System Platform

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INTRODUCTION

- **The lack of rich automation functionality between EHR platforms led to the following problems [13]:**
  - Reliance on inefficient automation processes that may introduce high risk errors in vital medical data.
  - Poor integration among patient information system units, which impact both patient care and the business's bottom line service quality.
  - Isolated patient information system units, which complicate the hospital's ability to follow an individual patient's care seamlessly from intake to treatment to aftercare.
  - Missed opportunities to capture revenue, and an inability to maintain customer relations and business process management.

Proposed Solution:

- Designing more seamless integration between various EHR middleware such BizTalk, WebSphere, and Red Hat within and between the healthcare organizations.

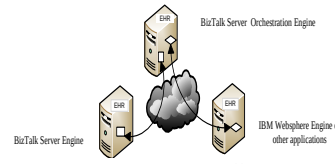

Figure 2 EHR to EHR integration [5]

- Providing a common ESB (Enterprise-Service Bus) technology will help reducing complexity of the EHR workflow and risks of a tightly coupling across the EHR systems.
- Employing SOA concept and Web Services technologies to design an integrated EHR system based on Microsoft BizTalk server as EHR middleware.
- As emerging technologies, semantic Web and SOA (Service Oriented Architecture) allow BPM (Business Process Modeling) System to automate business processes that can be described as services, which in turn can be used to wrap existing enterprise applications [10].

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INTRODUCTION

- Web service standards such as SOAP (Simple Object Access Protocol), XML (EXtensible Markup Language), XSD (*XML Schema Definition*), WSDL (Web Services Description Language documents), UDDI (Universal Description, Discovery and Integration) and WS-* specifications, such as WS-Security and WS-Policy, are the growing standards that connect enterprise capabilities across heterogeneous platforms.
- Microsoft provides standards-based products and technology to help the healthcare industries to integrate disparate IT environments resulting in more effective communication [4].
- Figure 3 below is scenario of how SOA technologies can be used to create a secure and real-time EHR central repository.

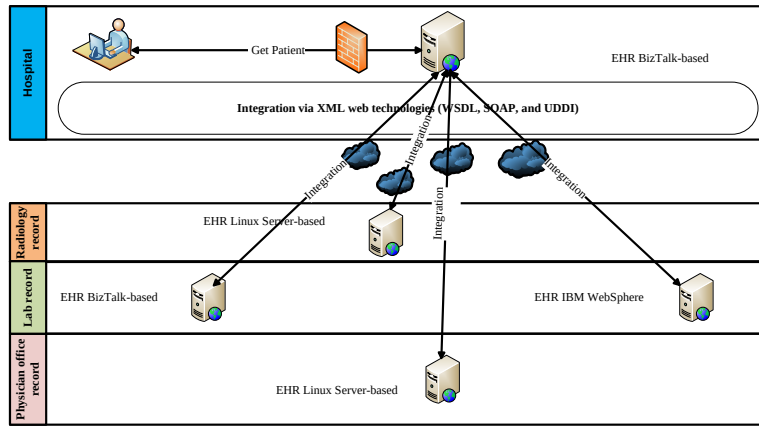

Figure 3 Integrated EHR Information Platform

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INTRODUCTION

SIGNIFICANCE OF PROBLEM

- In early 2008, only 4% of respondents were using a fully functioning EHR system and 13% were using a basic system [14].
  - 44,000 to 98,000 people die in hospitals each year as a result of medical errors that could have been prevented.
  - Medication errors caused 7,000 deaths.
  - Medical errors cost the U.S. $37.6 billion each year.

- This project are significant to the needs of designing an integrated EHR system in order to allow [12, 16, 17]:
  - Availability and accessibility of vital health information 24/7, regardless of where the person requiring care is located.
  - More efficient treatment since healthcare practitioners will be better positioned to spend more quality time with their patients.
  - Reduction of the number of redundant procedures; therefore, less health risks for the patient and greater cost savings.
  - Empowerment of individuals to exercise greater control over their own health.
  - Improvement of quality of care.

- Implementing a SOA to EHR system can improve the quality of delivery of healthcare information
- SOA brings added efficiency to EHR systems by offering deployable services interacting in a loosely coupled fashion [3].
- This project provides a noble opportunity to educate healthcare providers about the importance of using the SOA concept and Web Services technologies to resolve EHR integration problems and learn more about EHR development issue

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INTRODUCTION

STATEMENT OF PURPOSE

- The project will serve as a "proof of concept" to educate industry on the importance of achieving affective integration in EHR systems in the U.S.
- This effective integration will be done by establishing a common EHR engine that is accessible in demand by any healthcare provider using the Web services components.
- The project addresses the importance of using SOA concept and web services such as XML, WSDL, and SOAP in the areas of integration of healthcare industries' systems based on guidance from the Microsoft Healthcare Framework [4] to align with widely accepted principals and industry standards.
- The anticipated deliverables of the project are as follows:

- Investigation of the challenges that affect the integration of EHR and articulate the solution
- Evaluation of how SOA and Web services technologies improved the EHR systems integration, eliminates redundant data entry, and streamlines healthcare's workflow processes.
- Analysis of SOA technologies: XML, WDSL, HTTP, and SOAP.
- Introduction of how web services support systems coordination and enhanced security.
- EHR systems Integration designs.
- A proof of concept describing how Microsoft employs SOA concept and Web Services technologies to integrate EHR systems based on BizTalk server.
  - Microsoft approach to integration
  - BizTalk integration features, system security, and management options.
- Findings and recommendation.
- Future work needed based on Microsoft enterprise service bus implementations, namely the BizTalk server Engine.
- Conclusions relevant to the project return on investment (ROI) to healthcare sector and problems encountered.

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PROJECT OVERVIEW

EHR'S AUTOMATION HISTORY:

- There is compelling evidence that U.S. strived to develop workable integrated EHR models based on its national healthcare information infrastructure [12].
  - The department of Veterans Affairs (VA) implementation of VistA
  - Medicare Prescription Drug Improvement and Modernization Act
  - HIMSS (*Healthcare Information and Management Systems Society*) and RSNA (*Radiological Society of North America*) put together what was dubbed the IHE "Integrated Healthcare Enterprise).
  - Centers for Disease Control (CDC) and Federal Drug Agency (FDA) adopted ebXML for their data communication.
  - SOA was proposed for orchestration of the medical systems [22] to aid clinical decision support systems and integrate standards, such as HL7. SOA is an alternative approach for OMG (Object Management Group) and other approaches. There has been a resurgence of SOA, due to the advancement in XML-related technologies in general and Web Services in particular [21].
  - These examples are the attempts but not becoming comprehensive effective integration standards. This is because many hospitals lack even the capability to deliver laboratory and other results in an automated fashion.

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PROJECT OVERVIEW

DEFINITIONS

Term	Definition
EHR	An EHR is a digital collection of a patient's medical history and could include items like diagnosed medical conditions, prescribed medications, vital signs, immunizations, lab results, and personnel characteristics like age and weight [23].
Architecture	Architecture is a formal description of a system, defining its purpose, functions, externally visible properties, and interfaces. It also includes the description of the system's internal components and their relationships, along with the principles governing its design, operation, and evolution [3].
A service	A service is a software component that can be accessed via a network to provide functionality to a service requester [3].
SOA	The term SOA refers to a style of building reliable distributed systems that deliver functionality as services, with the additional emphasis on loose coupling between interacting services [3].
Integration	Integration is the arrangement of an organization's information systems in way that allows them to communicate efficiently and effectively and brings together related parts into a single system [24].
Interoperability	Interoperability is the ability of health information systems to work together within and across organizational boundaries in order to advance the effective delivery of healthcare for individuals and communities [25].
HL7	HL7 is a language which can enable the exchange and interoperability of medical records between patient administration systems (PAS), electronic practice management (EPM) systems, laboratory information systems (LIS), electronic medical record (EMR) or electronic health record (EHR) systems [26].

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PROJECT OVERVIEW

EHR COMMUNICATIONS SYSTEMS

- When compared to some countries, the U.S. seems to fall behind in EHR systems communication, which pose threats to maintaining quality of data standards imposed by HIPPA (the Health Insurance Portability and Accountability Act).

Table 2 EHR component, practice problem, and data automation scenario [28].

EHR Component	Practice Problem	Data Automation Scenario
Practice Management System	• Under-billing. • Inefficiency in scheduling	• Increased charge capture • Allows multi-site practices to conduct centralized scheduling
Basic Medical Charting System	Missing or illegible charts.	Providers have a legible, well-organized, electronic chart available immediately.
Results Management	Paper copies of test results arrive with no prior values	Improves efficiency by electronically linking test results with other patient information
Computerized Physician Order Entry (CPOE) and Electronic Prescribing (e-prescribing)	Adverse drug events Prescription writing is time-consuming and error-prone.	• System alerts notify providers by adverse drug event. • One-click refills allow providers to refill multiple prescriptions simultaneously and quickly with enhanced accuracy. • CPOE systems, together with e-prescribing, may decrease adverse events by 40%
Clinical Decision Support System (CDSS)	Chronic disease care can be complex and daily practice can interfere with adherence to preventive guidelines.	Evidence-based guidelines are readily available and reminders are provided during patient visits.
Query and Reporting System	• Difficulty in identifying subsets of patients with particular characteristics • Claims-based performance indicators may not accurately reflect clinical quality.	• Ability to track the performance in managing patients with specific chronic diseases or conditions • Practices can rapidly identify and contact subsets of patients who would otherwise be very difficult to identify.
Interfaces With Other Clinical Providers	• Needed patient information inaccessible.	• With appropriate confidentiality safeguards, providers exchange patient information summary in the event of admission or referral.
Remote Access Capability	• Inability to access full patient information remotely	• With appropriate security, access to patient information enhances information flow and reduces errors that result from a lack of up-to-date information.

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PROJECT OVERVIEW

SOA APPROACH TO INTEGRATION

- The major distinction between the SOA and web services is that SOA is architecture, while web services are technologies that implement an orchestration
- The service is the core element in SOA. Services communicate with other services and clients using standard, dependency-reducing, decoupled message-based methods. This characteristic is called loose coupling.
- The service provider has to publish the service description in order to allow the requester to find it.

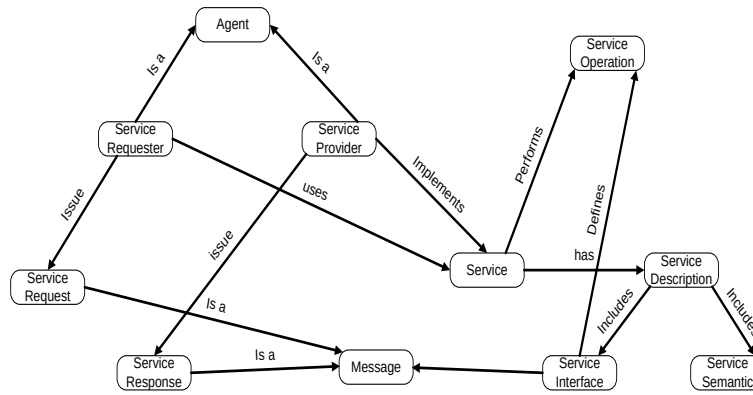

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Figure 4 SOA vocabularies in an abstract sense

PROJECT OVERVIEW

SOA APPROACH TO INTEGRATION

- SOA and Web Service use numerous standards and technologies in healthcare data interchange.

Table 3 Popular SOA infrastructure standards for healthcare

Standard, Specification	Organization	Category	Description
WSRP (Web Services for Remote Portlets)	OASIS	Integration	Interfaces and semantics which standardize interactions with components.
WS-BPEL (Web services Business Process Execution Language)	OASIS (Organization for the Advancement of Structured Information Standards)	Orchestration	Enabling users to describe business process activities as Web services and define how they can be connected to accomplish specific tasks
UDDI	OASIS	Discovery	A platform-independent, XML-based registry for automated services to be discovered and defined.
SOAP	W3C	Protocol	A protocol for exchanging XML-based messages over a computer network, normally using HTTP.
WS-I RSP (Reliable Secure Profile)	WS-I	Transactions	An interoperability profile dealing with secure, reliable messaging capabilities for Web services.
WSDL	WSDL	Discovery	An XML format for describing network services as a set of endpoints operating on messages containing either document-oriented or procedure-oriented information.
XML (info-set, namespace, schema)		Protocol	A remote procedure call protocol which uses XML to encode its calls and HTTP as a transport mechanism.
WS-SEC (Web services Security)	OASIS	Security	Provides a means for applying security to Web services.
WS-TX (Web services Transaction)	OASIS	Transactions	Defining protocols for coordinating the outcome of distributed application actions.

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PROJECT OVERVIEW

SOA APPROACH TO INTEGRATION

- The integrated system is viewed as a set of interactions among the services..

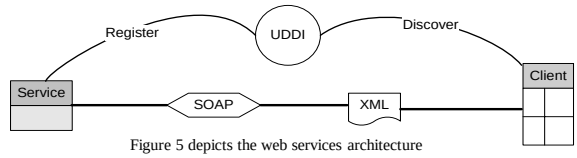

Figure 5 depicts the web services architecture

- SOA can be implemented using a variety of technologies, programming languages, and communication protocols [3].
- SOA offers a powerful support for common communication adaptability. Protocols such as HTTP, RMI (Remote Method Invocation), DCOM (Distributed Component Object Model), CORBA (Common Object Request Broker Architecture), etc can be used.

Table 4 distributed technologies communication protocols

	Web Service	RMI	CORBA	DCOM
Transport Protocol	HTTP	JRMP (Java Remote Method Protocol)	IIOP (Internet Inter-ORB Protocol)	ORPC (Object Remote Procedure Call)
Data Binding	XML schema	Primitive, Serialized objects	IDL (interface definition language)	MS IDL
Programming Language	Any (with XML parser, SOAP composition)	Java	Any (with IDL mapping standards)	Many (C++, Java, VB, etc.)
Interface Description	WSDL	Interface of server objects	IDL	MS IDL
Remote Call	By SOAP message	Get references of server objects	Get reference of server object	Get Pointer of server objects
Routine	Stub Proxy DII (Dynamic Invocation Interface)	Client: stub or proxy Server: skeleton	Client: stub or proxy Server: skeleton	Client: proxy Server: stub

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PROJECT OVERVIEW

SOA APPROACH TO INTEGRATION

- The Enterprise Service Bus (ESB) is a broker infrastructure which offers an alternative integration of legacy business systems by converting them all to services.
- ESB is not mandatory in SOA but is usually used in large (enterprise) systems with many services.
- The ESB might be implemented as a distributed, heterogeneous infrastructure.
- Many companies such as Microsoft, IBM, Systinet, Kapow BEA WebLogic technology, Cape Clear, Sun Java, Oracle, IONA Celtix, Apache Beehive Project, established SOA and web-services development environment based on a particular server known as ESB.

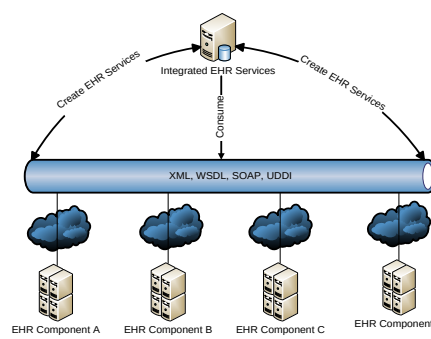

Figure 6 EHR Solution Scenario

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PROJECT OVERVIEW

ANALYSIS OF SOA TECHNOLOGIES

- SOA orchestration can be implemented on RPCs Jini, COBRA or other technologies [35]. However, most SOAs today are built through web services and REST (Representational State Transfer)
- Popular standard technologies used for implementing web services include:
  - RPC (remote procedure call) a mechanism through which a program software module one computer can communicate and interact with a program on another computer. . Software modules using RPC to communicate to one another have to be tightly coupled with each other, which violate the loose coupling aspect of SOA.
  - Web services are built of the following components illustrated in Figure 7:

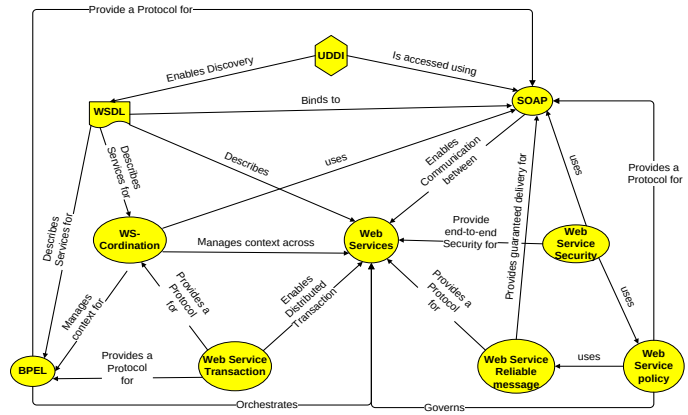

Figure 7 SOA technologies interaction

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PROJECT OVERVIEW

WEB SERVICES COORDINATION

- Standardization on a coordination framework that allows users and services to register with it and customize it on per service or per application basis is needed.
- WSCF (Web Service Contract-First) [37] defines a sharable mechanism to manage context augmentation and lifecycle, and guarantee message delivery.
- UDDI, in conjunction with XML, SOAP, and WSDL, form the core set of base protocols for Web services that vendors such as Sun, Oracle, Microsoft, IBM, and BEA have all agreed to support.
- IBM, Microsoft, and BEA introduced a set of Web services standards for automating business processes on the Web such as BPEL4,WS-Coordination for specifying an extensible framework for the coordination of actions of distributed applications, and WS-Transaction for coordination types that are used with the framework described in WS-Coordination.
- For medical Web services, business partners are correlated by IHE (*Integrating the Healthcare Enterprise)* transactions. A unique ID generator can be used instead.
  - As an example for compensation-based transaction processing, the patient registration transaction uses a HL7 ADT^A01 or A04 message to register a patient. In case of an error in the sending application, the registration process has to be undone with the A11 cancel message. If a patient is pre-registered (A05) the A38 cancel message is used [38].

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PROJECT OVERVIEW

WEB SERVICES SECURITY

Table 5 A framework for building security protocols.

Aspects of security and privacy concerns needed for EHR systems integration include [39]:	Web services security can be described as [40, 41]:
• Hacking incidents on EHR systems • Misuse of health information records • Long term data management concerns • Government or corporate intrusion • Broken Access Control/Bad Policy Enforcement • SQL Injections (security vulnerability occurring in the database layer of an application) • XPath Injections (denial of service vulnerability) • Capture and Replay Attacks • DOS (attacker attempts to prevent legitimate users from accessing information or services) • Large Payloads • External Entity Attacks • XML Bombs (denial-of-service attacks) • XML-based can traverse firewalls and VPNs (virtual private network). • Medical data transferred is often highly confidential and large data-sets. • Encryption mechanism can force tight coupling between the healthcare partners [15].	• Web Services Security specifications approved by OASIS in October 2003 • The WS-Security specification was created as part of the GXA (Global XML Architecture) o Originally authored by Microsoft, IBM, and VeriSign and was released in October 2001 • Security information can be username/password, X.509 certificate, Kerberos binding, SAML (Security Assertion Markup Language) assertion, XrML (eXtensible Rights Markup Language) token, biometric information, etc. Security token include • Supports end-to-end SOAP message security • Support for pluggable algorithms • Encryption, digest, signature, canonicalization, transforms. • The World Wide Consortium has issued three XML-based standards for security [43]. o XML Key Management Services - digital signatures are used to authenticate a message's source. o XML Encryption - this protects the privacy of the message. o XML Key Management Services - public key registration and validation.

- In April 2002, IBM and Microsoft published joint XML standards as shown in the table 6 below [43]

WS conversation, 2002	WS federation	WS authorization
WS policy	WS trust	WS privacy
WS security		
SOAP foundation		

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PROJECT OVERVIEW

ASSUMPTIONS

- The introduction of an SOA concept and web services would improve healthcare in the U.S.
- U.S. healthcare providers are willing to share health record data across institutions in realization of integrated EHR systems.
- Integration of the EHR systems decreases the cost of healthcare delivery system.
- EHR data will be retained in its original location but be available for view in an aggregated manner.
- By implementing these conditions, the EHR systems will be most effective for the patient as well as the major healthcare providers.

DELIMITAIONS

- Because the amount of EHR data can be incredibly large, the project is delimitated to an EHR system of United States.
- The implementation platform of this project will be based on Microsoft platforms, although the methods discussed may still apply to various software environments.
- The aspect of how caregivers gather and present healthcare information is beyond the scope of the project.
- The project focuses on technological aspects of EHR system and not how its data is interpreted medically.

LIMITAIONS

- The project relies only on perceptions of technology acceptance, rather than actual usage behavior.
- The post-implementation behavior may differ from this project perceptions or intentions to use the EHR technology.
- The study is also limited by prior healthcare experinces, which might affect the attitudes about EHR system adoption.
- Recommendations or results from this project are not indicative of behaviors or attitudes of doctors, nurses, hospitals, clinics, laboratories, pharmacies, and other players working in health systems with different types of EHR systems.
- This project is not supported or financed by any healthcare provider.
- Software coming from different perspectives within the same project is often written in different programming languages [29]. Probably this constrain increases the possibility of having run-time problems when the programs try to interoperate.
- Other programming languages such as Java, C++, and so forth other than XML and C# are not employed to conduct this project.
- Barriers to successful EHR adoption in the United States such as demographics, politics, and cultural perceptions may work against the goals of this project.

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EHR SYSTEMS INTEGRATION

- Health informatics is substantially standards based.
- The top down approach is used to harness the existing EHR applications by orchestrating legacy and heterogeneous systems in to common platform.
- The dependences between enterprise SOA are defined by a bridge (ESB)
- ESB is a mechanism to expose, register, and discover EHR services or interfaces using web services technologies.
- ESB perform message transformation and translation between different destinations or between B2B standards and protocols and provide security to the proposed EHR system.
- Unified Modeling Language (UML) is employed to design the proposed EHR integration scenario as a set of graphical notation techniques to create abstract BPM of EHR systems that rely on ESB.

- Three kinds of integration scenario of EHR systems are describe using UML.
  - General conceptual view of EHR systems that support heterogeneous integration needs.
  - Logical view of EHR platform to support the solution architecture components for EHR conceptualized services.
  - Physical view to indentify the physical components of EHR services and their characteristics.

  - The objective is simply to improve EHR business process, in alignment with the principals of SOA, to meet the growing business demands, and increased competition threats more efficiently.

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EHR SYSTEMS INTEGRATION

- SOA services are implemented as Web services, in which EHR systems communicate with each other using XML messages transported over the Internet [34].
- The WSDL provides a method of creating an explicit interface containing the return values, parameters, method names, protocols, and IP addresses so that external applications may remotely access the Web services components published on the web by referring to the information recorded in UDDI [37, 38].
- Technology standards such web services, AD (Active Directory), LDAP (Lightweight Directory Access Protocol), HTTP, etc., is supported by the proposed ESB platform in order to fully support the requirements of SOA and the proposed EHR integration.

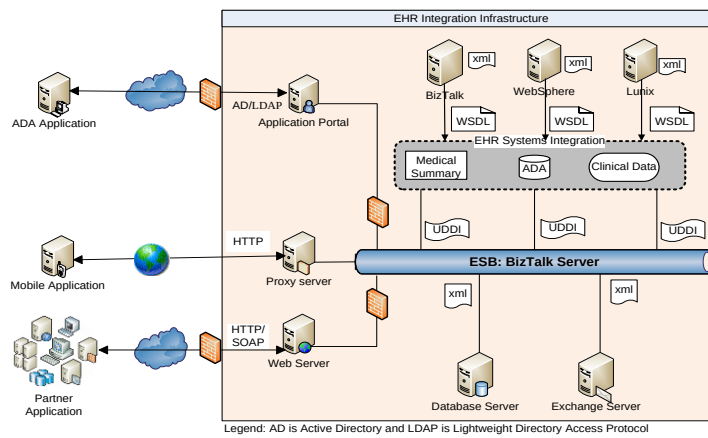

Figure 8 Conceptual view of EHR systems to support EHR integration needs (author design-based

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EHR SYSTEMS INTEGRATION

- The proposed components of EHR services and their characteristics based on ESB platform to support healthcare systems integration solution architecture is given in Figure 10 below.
  - ***Patient care:*** registration, medical, and in/out patient management.
  - ***Administration:*** resources allocation, payroll, purchases, inventory, accounts,
  - ***Querying services:*** provide the information related to internal and external entities of the system. It allows external entities that use heterogeneous systems such as Websphere, Linux, and BizTalk systems can access the details of patients through these ESB services.
  - ***Nonfunctional services***: message or notifications mechanism for exchanging EHR data, shared data access based on web services standards, services manager provides policy, user authentication and access controls for verifying a user through a username and password.
  - ***Reporting services:*** general covers reporting aspect of the system like inventory usage and lab cover the reporting aspect of medical report. The lab reports should be compliance with standards specified by HL7 and HIPAA.

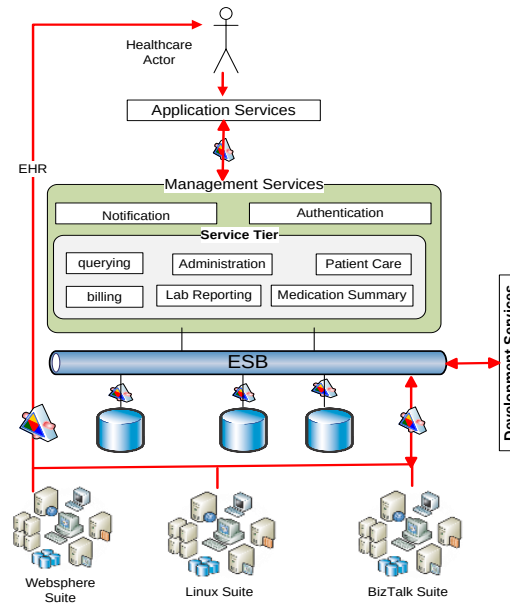

Figure 9 logical view of HER platform (author design-based)

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EHR SYSTEMS INTEGRATION

- Vendors offered technology suites of their own content to help the users integrating heterogeneous EHR platforms by using SOA concept and web services technologies.
- Popular ESB products are:
  - IBM WebSphere ESB
  - Microsoft BizTalk server
  - Oracle SOA Suite
  - Linux Red Hat
- Different ESB vendors have different strategies. This has led to many definitions of ESB which in turn led to the emergence of ESB products that are very different from each other.
- The ESB products in the market can be categorized into one of the following [15]:
  - Enterprise Application Integration (EAI-based) products: These kinds of ESBs are built on EAI products. Many EAI vendors position their products as ESBs by adding many open standards to the existing proprietary formats of communication.
  - Service-based architecture: these are products built on architecture standards and specifications that support service based integration.
  - Web Services standards compliant solution these are products that are just implementations of a collection of WS standards.

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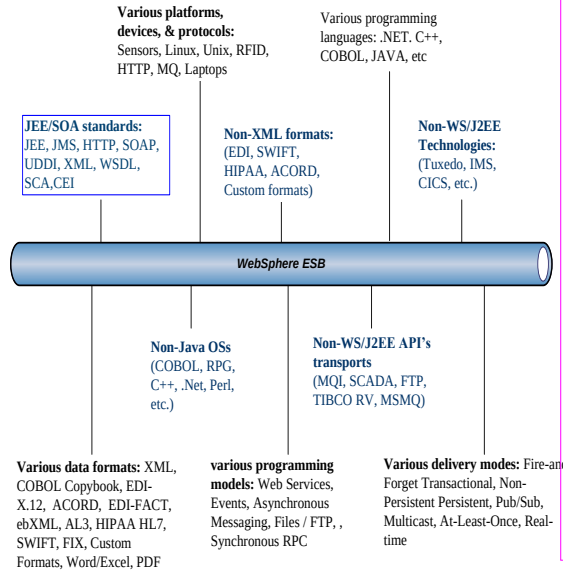
EHR SYSTEMS INTEGRATION

IBM Websphere ESB Technologies



IBM ESB technologies

- Strengths
  - IBM has a closely aligned software and professional service that is strongly focused on SOA.
  - The company has a huge and growing installed base, and a widely recognized brand for its WebSphere product.
  - IBM has a comprehensive application infrastructure offering for new SOA applications.
- Cautions
  - The WebSphere product set is still complex to deal with and expensive to build skills for deploy and operate, especially when multiple components must be used.
  - Some critical products for new SOA applications such as WebSphere Process Server and WebSphere ESB, still experiencing technical and adoption challenges.
  - The company's vision for middleware support for cloud computing and APaaS (Software as a Service) is still in the making phase.

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Figure 10 WebSphere Message Broker [46].

EHR SYSTEMS INTEGRATION

Oracle SOA Service

- Oracle Fusion Middleware Suite can work with both Oracle and non-Oracle SOA applications.
- SOA 2.0 combined SOA and event driven architecture, which provides the ability for the system to external events and notifications.

- Strengths
  - Oracle has a comprehensive set of technologies for new SOA applications (user experience management, enterprise application server, ESB, BPM technology, BAM, integrated business intelligence, complex-event processing (CEP), development tools, metadata management, SOA governance, security and management tools).
  - Oracle's application infrastructure offerings include advanced features for event processing (light-weight event-driven server and a CEP engine) and XTP (including, distributed caching platform [Coherence] and advanced Java Virtual Machine features [JVM; JRockit], addressing real-time processing and application infrastructure virtualization requirements).
  - The company provides OSGi-based (Open Services Gateway initiative) modular and pluggable microkernel architecture for application server and SCA support, paving the way for an advanced, highly scalable foundation.
- Cautions
  - The massive effort to integrate BEA Systems' technologies into Oracle's original products will absorb significant Oracle R&D resources, may risk slowing the pace of innovation and may expose the installed base to inconsistencies in the migration path.
  - The worldwide process for integrating BEA Systems' sales and support organization is still in progress in several countries, and may slow down Oracle's momentum in the middleware business.
  - Convergence of user experience technologies in the strategic Oracle WebCenter is still in the making and requires integration and rationalization of multiple portal and Web 2.0 products, deriving from BEA Systems and Oracle developments.
  - Oracle a still limited vision for a middleware role in cloud computing and APaaS

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EHR SYSTEMS INTEGRATION

Linux Red Hat

- Red Hat thus becomes the vendor of choice for companies using open source Linux. Open source has spread into the SOA space.
- Examples of open source SOA tools are JBoss, and Logic Blaze for ESB, and SOA related software. The JBoss bundle is called the JBoss Enterprise Middleware Suite (JEMS). The JEMS offering includes Hibernate, Apache, Tomcat, JBoss, JBoss Portal, Messaging, Cache, and an applications server. The JBoss Eclipse development environment enables development and testing of SOA applications.

- Strengths
  - The growing momentum for open source in Red Hat's mainstream prospect base, especially in this difficult economic climate, offers the company new business opportunities.
  - The combination of a leading, open-source operating system (RHEL) and a dominating open-source application server technology (JBoss) positions the company as a leader in open-source enterprise computing markets.
  - Advanced engineering talent and the large pool of technologies in the JBoss.org family and beyond in the open-source communities allows rapid expansion of Red Hat's offerings.
  - The consolidated business model of Red Hat Linux and JBoss product lines builds on Red Hat's proven record and improves the business performance of the JBoss division, yet preserves the relative independence of the JBoss application infrastructure business.
- Cautions
  - Red Hat is still not certified compliant with the current Java Platform, Enterprise Edition (Java EE) 5 specification (although the key capabilities of the specification are available short of certified compliance) — a sign of a lack of management urgency for the public competitiveness of the technology.
  - Limited SOA modeling, design and development tools reduce the offering to mostly technically advanced projects (the recently acquired MetaMatrix data integration tool may be a prototype for future improvements in this area).
  - The SOA support technologies (the open-source JBoss ESB, JBoss BPM, JCache, Java UDDI [jUDDI] and JBoss Rules) are improving adoption, but still require larger numbers of production mainstream deployments to be proved.
  - The company faces a growing challenge from Sun Microsystems (GlassFish) and continuing pressure from IBM (WebSphere Community Edition) to Jboss.

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EHR SYSTEMS INTEGRATION

- As shown in figure 12, multi-channel access for heterogeneous systems and applications should be considered beyond single hospital or healthcare provider

- One advantage with this middleware EHR architecture is that gives the healthcare provider larger flexibility to choose different vendors for the databases, applications, and user interfaces.
- A prerequisite for this flexibility is that the interfaces between the layers should be well defined and accessible publicly.
- This proposed ESB systems Integrate EHR system and business logic into new applications or business processes without having to replace code or make costly application rewrites

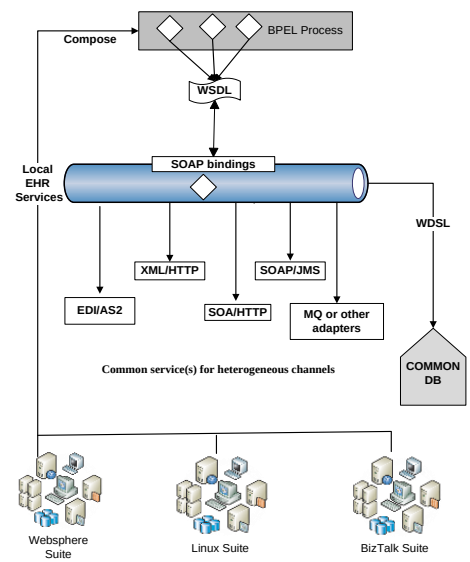

Figure 11 Multi-Channel Access for heterogeneous systems

Legend: EDI-*Electronic Data Interchange, AS2- Applicability Statement 2*

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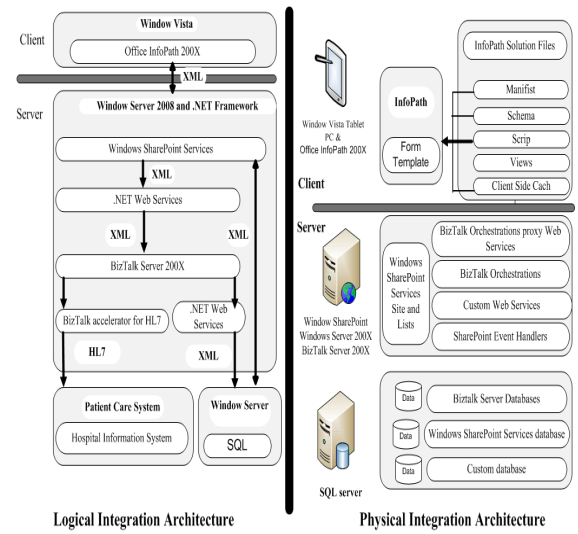
EHR SYSTEMS INTEGRATION

MICROSOFT APPROACHES TO INTEGRATION



Microsoft BizTalk Technologies

- In October of 2006, Microsoft introduced its Business Process and Integration platform BizTalk server that uses an SOA[35].
- Strengths
  - proven reputation in markets
  - Microsoft application platform technologies are deeply integrated with the Windows operating-system family.
  - Strong technical performance of Microsoft .NET application platform .
- Cautions
  - All software is available on the Windows operating-system family only.
  - The SOA vision is modestly executed, and the late-start support for SOA is still mostly manifested by support for Web services.
  - There is no integrated SOA-enabling technology. Support for events is isolated in BizTalk and is disconnected from other SOA initiatives.
  - Microsoft's business model and company culture are still not well-suited for conservative, high-end enterprise IT, with its long sales cycles, interest in long-term account relationships and intolerance of discontinuities

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EHR SYSTEMS INTEGRATION

MICROSOFT APPROACHES TO INTEGRATION

Table 7 system integration standards, legacy integration standards, and authentication Standards

Consumer uses cases	Supported Standards
Integrate BizTalk Server with host applications using IBM WebSphere MQ	FTP, HTTP, SOAP, WS-*, XML
Integrate UNIX environments with Microsoft technologies	FTP, HTTP, IP, IPSec, LDAP, PKI, POSIX standards, S/MIME, SSL, TCP, Telnet, TLS, XML
Integrate Novell NetWare environments with Microsoft technologies	DNS, HTTP, IP, IPX, Kerberos protocol, LDAP, NBIPX, PKI, SAP, TCP, Token Ring, SPX, SSL, X.509
Integrate message queues between a host system and .NET-based environments	C# CLI, Visual Basic .NET
Connect .NET applications with IBM mainframe and AS/400 systems	DRDA, HTTP, IP, Kerberos protocol, LU 6.2 protocol, OLE DB, SNA, SOAP, SSL, TCP, TLS, UDP, WS-I Basic Profile, WS-*, X.509, XML
Connect Microsoft SQL Server® to IBM DB2 databases	HTTP, IP, OLE DB, SOAP, TCP, WS-*, XML
Support for Fortran, RPG, and COBOL	C# CLI, Visual Basic .NET
Connect to SQL Server from IBM WebSphere Application Server	JDBC 3.0, JTA, SQL, TDS 7.2, XA Protocol
Compile and run UNIX applications on servers running Windows	HTTP, IP, IPSec, FTP, LDAP, PKI, POSIX standards, S/MIME, SSL, TCP, Telnet, TLS, XML
Connect to IBM DB2 databases using managed code	C# CLI, LU 6.2 protocol, OLE DB, SNA, XML
Enable identity authentication and management for enterprise environments	Kerberos protocol, LDAP, WS-I Profiles, WS-Security
Enable host single sign-on scenarios	DRDA, HTTP, IP, Kerberos protocol, LU 6.2 protocol, SNA, SOAP, TCP, WS-*, X.509, XML

Legends: IPsec-Internet Protocol Security, PKI -public key infrastructure, POSIX-Portable Operating System Interface, S/MIME-Secure/Multipurpose Internet Mail Extensions, SSL-Secure Sockets Layer, TCP-Transmission Control Protocol, TLS-Transport Layer Security, DNS-Domain Name System, IPX-Internetwork Packet Exchange, NBIPX-NetBIOS over IPX, SAP-Service Access Points, SPX-Sequenced Packet Exchange, DRDA-Distributed Relational Database Architecture, LU 6.2-Logical Unit *6.2*, OLE DB-Object Linking and Embedding, Database; *SNA*-Systems Network Architecture, UDP-User Datagram Protocol, *WS-I*-Web Services Interoperability, *JDBC*-Java Database Connectivity, *TA*-Java Transaction API, and SNA-Systems Network Architecture.

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EHR SYSTEMS INTEGRATION

BIZTALK INTEGRATION FEATURES

- BizTalk Server 2006 includes a range of SOA technologies to support EAI and B2B goals [5].
- An adapter is an implementation of a communication mechanism, such as a particular protocol.
- BizTalk Server and Window Workflow foundation (WF) platforms can interoperate using the BizTalk Server Adapter for SharePoint.
- Due to the configuration problem that associated with BizTalk environment, this project defines the BizTalk server features without actual testing.

This project uses the following Microsoft technologies and software to build an integrated SOA-based EHR system using BizTalk Server 2006 engine.

- Windows Server enterprise edition 2003
- Components to architect and automate the EHR care system
  - Microsoft BizTalk Server 2006 as the key integration technology utilizing HL7 and HIPPA accelerators
  - Microsoft Office InfoPath® 2007
  - Microsoft SQL Server™ 2005 as the clinical data repository
  - Microsoft Windows Server® 2003
  - Microsoft Office SharePoint® Server 2007
  - Exchanger server
  - .NET Framework as the key infrastructure
  - IIS (Internet Information Server)
  - Active Directory
  - Visual Studio 2005
  - SharePoint

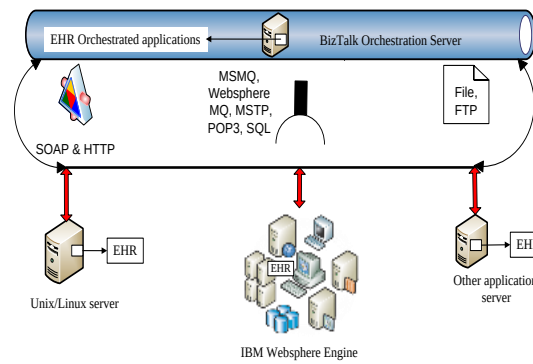

Figure 13 BizTalk Messaging Engine with several adapters for system integration

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EHR SYSTEMS INTEGRATION

BIZTALK INTEGRATION FEATURES

- Microsoft adapters are pluggable software components (written in either .NET or COM) that support the integration between BizTalk and various applications (custom and/or Enterprise resource planning (ERPs)), protocols, platforms, and technologies. Figure 15 is a screen shot of BizTalk server 2006 Administration console showing various adapters including those for DB2, SQL, etc.

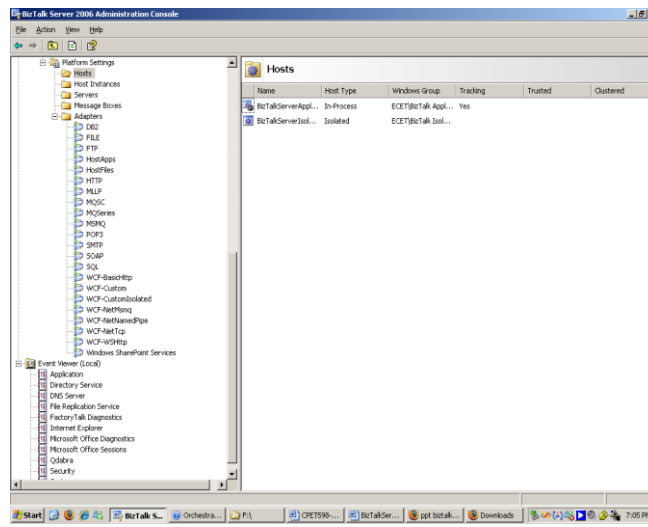

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Figure 14 screen shot of BizTalk 2006 and administration console

BIZTALK INTEGRATION FEATURES

A short description of native adapters that ship directly with BizTalk server 2006 is shown in Table 8

Web services Adapter	Supports sending and receiving messages using SOAP over HTTP.
POP3	The POP3 Adapter is a Receive-only protocol Adapter in BizTalk Server 2006 that can be used to retrieve messages from a particular email account via the POP3 protocol. This Adapter can be used for system or human interaction. See *http://msdn2.microsoft.com/en-us/library/aa546737.aspx* .
File Adapter	Supports reading from and writing to files in the Windows file system.
FTP Adapter	The FTP Adapter is a protocol Adapter in BizTalk Server 2006 which can receive or send messages to FTP-based servers. See *http://msdn2.microsoft.com/en-us/library/aa561215.aspx* for more information about using the FTP Adapter
HTTP Adapter	The HTTP Send Adapter is a .NET-based Send Adapter which will POST an HTTP request to an arbitrary HTTP endpoint based on the Send Adapter configuration. See http://msdn2.microsoft.com/en-us/library/aa577953.aspx for more information about these two complimentary Adapters.
MSMQ	Supports sending and receiving messages using Microsoft Message Queuing (MSMQ. MSMQ allows BizTalk Applications to communication with other applications in an asynchronous manner even if the other application isn't currently running (is down or disconnected). See http://msdn2.microsoft.com/en-us/library/aa559257.aspx.
MSMQT Adapter	Supports sending and receiving messages using BizTalk Message Queuing (MSMQT). MSMQT is an implementation of the MSMQ protocol that can receive and send MSMQ Messages into the MessageBox.
WebSphere MQ Adapter	Supports sending and receiving messages using IBM's WebSphere MQ (formerly known as MQSeries). for more information about this Adapter and its capabilities, see http://msdn2.microsoft.com/en-us/library/aa547973.aspx
SMTP Adapter	Supports sending messages using SMTP. Standard e-mail addresses are used to identify the parties. http://msdn2.microsoft.com/en-us/library/aa578267.aspx.
POP3 Adapter	Supports receiving e-mail messages and their attachments using version three of the Post Office Protocol (POP3)
WSS Adapter	Supports accessing and publishing documents stored in Microsoft Windows SharePoint document libraries
SQL Adapter	Supports reading and writing information to a SQL Server database
Base EDI Adapter	Supports sending and receiving messages in the electronic data interchange (EDI) format

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BIZTALK INTEGRATION FEATURES

- Most BizTalk Server 2006 artifacts are created in Visual Studio 2005 and compiled into .NET assemblies. Once compiled into an assembly, the artifacts are then deployed into the BizTalk Server 2006 configuration database, as well as added to the .NET Global Assembly Cache (GAC).

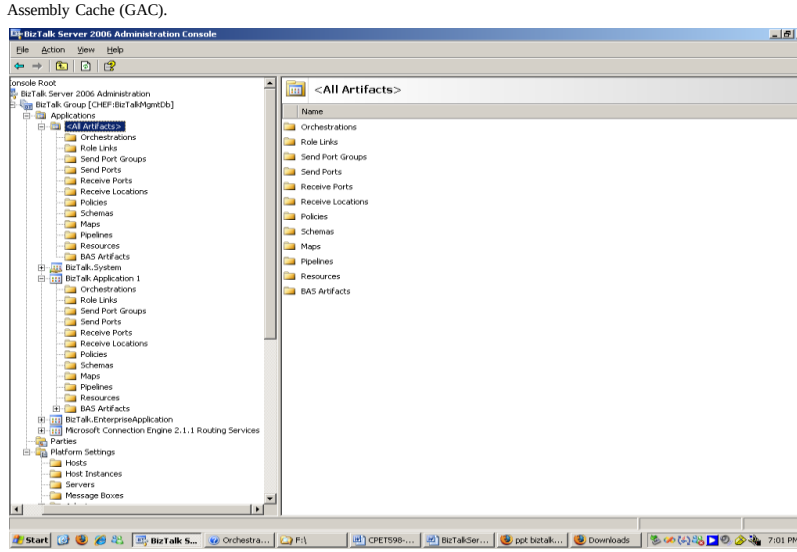

Figure 15 feature of BizTalk 2006 artifacts

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BIZTALK INTEGRATION FEATURES

- The main tool for managing the BizTalk Server 2006 engine is the BizTalk Administration console, which provides a new user interface for BizTalk Server 2006 administrators. The BizTalk Administration console as shown in Figure 16.

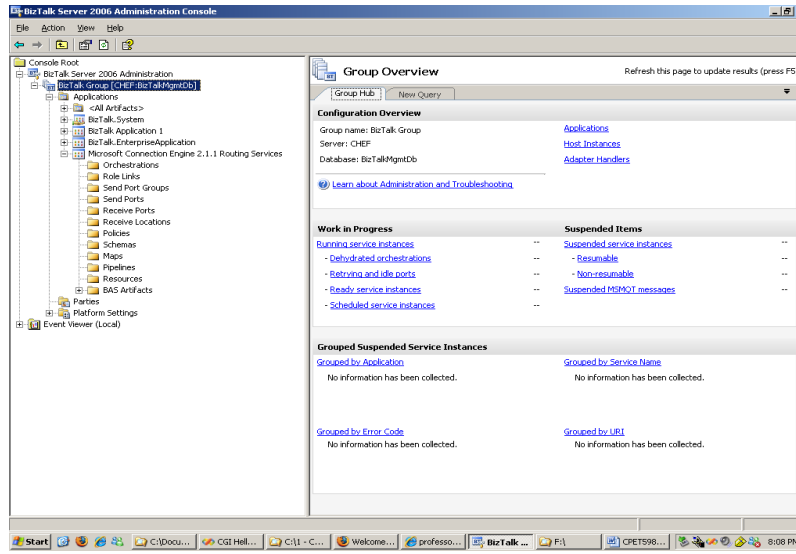

Figure 16 feature of BizTalk Administration console

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BIZTALK INTEGRATION FEATURES

- BizTalk Server 2006 supports mapping between different XML schemas and other features that aren't available in BPEL.
- Orchestration Designer runs inside Visual Studio 2005.
- Visual Studio 2005 is not recommended for deploying BizTalk Server 2006 Applications from development to test to production.
- The recommended way to take an Application from one environment to another is to create a Windows Installer File (.msi) which can then be used to import and deploy the Application to other environments (like from development to test to production).
- As shown in Figure 17, each map is expressed as a graphical correlation between two XML schemas that defines a relationship between elements in those schemas.

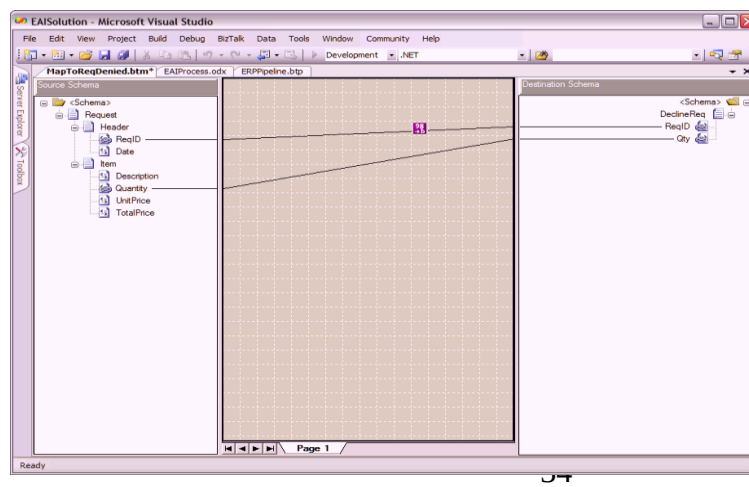

Figure 17 orchestration designer runs inside Visual Studio 2005

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BIZTALK INTEGRATION FEATURES

- Figure 18 depicts the logical and physical integration architecture

- SharePoint Services is a portal server that can be customized according to the specific need, includes security and integration capabilities, acts as a library of the clinical forms in a healthcare system, used by patients and Healthcare professionals to access EHR information.
- InfoPath role is:
  - Streamlining the process of gathering, using, and sharing information through electronic business forms.
  - Designing forms based on a schema, database, or a web service and publish the manifest to a portal, FTP, or shared folder.
  - Sharing the XML messages with the reference to a published URL

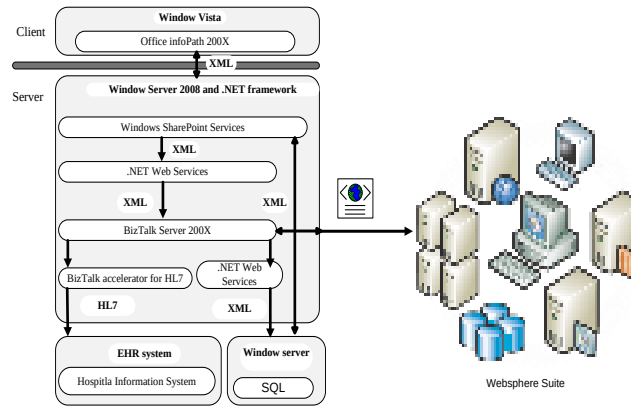

Figure 18 Logical and Physical Integration Architecture

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BIZTALK SECURITY AND MANAGEMENT

BizTalk Server offers the following security and management tools:

- **Message Encryption/Decryption**. See *http://msdn2.microsoft.com/en-us/library/aa559690.aspx* for more details.
- **Digital Signature Assignment**. Through its SMIME infrastructure, BizTalk Server 2006 can control what messages are routed to what partners and how those messages are encrypted. *See* *http://msdn2.microsoft.com/en-us/library/aa578450.aspx*.
- **Digital Signature Authentication.** The SMIME Pipeline component can be used to authenticate incoming messages. See *http://msdn2.microsoft.com/en-us/library/aa559539.aspx*.
- **SMIME Encoding/Decoding.** BizTalk Server 2006 includes Pipeline components which can encrypt and decrypt messages using the SMIME standard. See *http://msdn2.microsoft.com/en-us/library/aa562169.aspx*.
- **Custom Encoding/Decoding**. The BizTalk Server 2006 pipeline component architecture is open, allow for custom encode and decode components for operations like compression or decompression or custom encryption schemes.
- **Disaster Recovery**. BizTalk Server 2006 provides hooks to allow you to make a detailed disaster recovery plan based on your particular configuration. See *http://msdn2.microsoft.com/en-us/library/aa547565.aspx* .
- **Extensible Backup Framework**. BizTalk Server 2006 includes jobs and scripts that allow you to customize the backup of the BizTalk Server 2006 databases, including supporting log shipping. See *http://msdn2.microsoft.com/en-us/library/aa560972.aspx*.
- **Database Scale Out (Message Box).** All messages in BizTalk Server 2006 run through the MessageBox. When optimizing a BizTalk Server 2006 Group for performance, one of the main areas to analyze is the MessageBox. See *http://msdn2.microsoft.com/en-us/library/aa577486.aspx*.
- **Archiving & Purging.** BizTalk Server 2006 allows customizable tracking of messaging and execution data. For more details, see *http://msdn2.microsoft.com/en-us/library/aa560754.aspx* .
- **Database Clustering**. To support a highly available BizTalk Server 2006 environment, the BizTalk Server 2006 databases can be clustered in an Active/Passive cluster. See *http://msdn2.microsoft.com/en-us/library/aa577514.aspx* for best practices relating to clustering the BizTalk Server 2006 databases.

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FINDINGS AND RECOMMENDATIONS

- Installing and configuring BizTalk 2006 R2 is a time-consuming and complex process.
- It is necessary to conduct extensive research before attempting to install and configure BizTalk Also.
- Some components in test environment were set up for future use and expandability to support the needs of the Department of Computer and Electrical Engineering Technology & Information Systems and Technology.
- BizTalk server is at the heart of enterprise integration and interoperability nervous system and looking at how HCE and XDS.b (Cross-Enterprise Document Sharing-b) could come to complement one another.
- Some key recommendations to support rich HER's automation functionalities are:
  - Designing more seamless business integration between various EHR middleware to support more SOA systems integration is recommended to reduce integration costs and customization challenges.
  - Adoption of an initiative to migrate to a national EHR architecture and development of common web-services on a regional and national level to support EHR middleware is required.
  - Transforming to a comprehensive SOA-based EHR platform should start with small pilot project where an ROI value can be estimated before hand and subsequently evaluated once the SOA is operational.
  - All heads in the healthcare organization must work together with IT to establish and update company wide web services coordination policies and evaluate security threats to system by alerting the respective authority when critical situations arise.
  - Healthcare providers should tackle the issue of security and privacy in a very diligent and holistic way. A concerted effort, at every layer of EHR infrastructure, strict policies and use guidelines, and accurate monitoring capabilities are needed. With the imminent outlays proposed by the U.S President in 2009 to modernize the health care system, security consideration in integrating EHR systems is became must [40].
  - Advance SOA design and new generations of software and Web services technologies are needed to ensure EHR operational effectiveness and secure loosely coupled applications
  - Working with participants from healthcare professionals and industries is needed to achieve the desired comprehensive automation between EHR systems.

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FUTURE WORKS

- New strategy in the development of EHR applications should be introduced and new tools of adopting SOA concept and web services strategy in order to integrate EHR systems in *one standard platform* should be developed.
- The needed SOA-based EHR platform may be based on ESB and the lessons learned from software companies such as Microsoft, IBM, Linux, etc. in integrating EHR.
- The development of unified EHR systems should be started by structuring of existing healthcare information systems in the U.S. and develop a national middleware platform. Also, it requires adoption of an initiative to migrate to a national architecture and development of common web-services on a regional and national level
- More studies on the relationships between EHR applications are needed.
- Greater security planning for integration of EHR heterogeneous and legacy systems must be considered. Having a firewall could give corporations a false sense of security to corporation because SOA message are built to travel over HTTP or HTTPS, bypassing firewalls and thus allowing hackers to attack systems and access confidential information [35].
- Additional ESBs that allow Web services implementation should be used to evaluate the integration of EHR systems and to compare the results with the experiences from BizTalk server, WebSphere and other servers.
- The modeling process, especially the mapping between heterogeneous EHR systems, using UML and BPEL for EHR workflows design to create semi-automated processes that are able to define EHR Web services for SOA-based workflows will be tried in the near future.

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CONCLUTION

- The main challenges of healthcare information systems that affect the integration of EHR systems in the U.S. were investigated, SOA approach to integration was introduced, and then the technologies that used to implement SOA-based EHR system was described. Furthermore, the conceptual, logical, and physical views of EHR system were designed.
- Overview of Microsoft approach to integration and current state of SOA based on BizTalk server were presented. Findings, recommendations, and future paths in the evolution of SOA technologies were introduced.
- Some findings from analysis are:
  - The adoption of SOA has been slow in healthcare.
  - SOA gives a new approach for connecting heterogeneous systems in a standardized way, although each system may still have their own proprietary interfaces.
  - SOA technologies show promise in achieving EHR systems integration at reduced cost by leveraging existing investment in legacy and heterogeneous systems.
  - The federated architecture that SOA introduces, with its agnostic solution logic and loosely coupled applications, enhances the return on investment (ROI) by supporting reusable logic that decreases maintenance requirement efforts and allows healthcare sector continue to experience growth.
  - Web services improve EHR's workflow flexibility by offering the possibility of creating new business process from existing ESB such BizTalk infrastructure.
  - BizTalk provides core messaging and orchestration capabilities that allow developers to use the Business Rules Engine to address complex business scenarios, the Health and Activity Tracking tool to debug and examine BizTalk applications, and Enterprise Single Sign-On to create more secure environments.
  - The disadvantage of ESB is that the disparate systems must adhere to some messaging standards, which make ESB components tightly coupled [35].

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- This project provides me with a noble opportunity to gain solid knowledge about healthcare information systems and learn more about how other people approached EHR development issues. Because the healthcare sector is growing and hardly an outsourcing sector, the chances of getting a career in a similar IT field are promising.

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Thank You!

Any questions?