Medical Center Operational Systems Data Integration

Author: Elizabeth Peacock

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Executive Summary

In this enterprise architecture solutions report, a medical center initiative to integrate its isolated financial and clinical information systems is described. Focused senior management commitment is needed to coordinate stakeholder cooperation. Systems integration interoperability opens up opportunities for intelligent enterprise knowledge-sharing and improved standards compliance process.

Key stakeholder support is engaged through issues education and participation in business scenario workshops. A Coherency Management program to secure community cooperation and collaboration is engaged, followed by senior management stepping into the roles of chief communicators and consultants. TOGAF ADM is chosen as the enterprise architecture (EA) framework, complemented by the III-RM reference model to support the requirements of medical center intranet communication.

Systems integration centers on dynamic data warehousing applica-tions with Enterprise Information Integration (EII) data preparation and interactive metadata. Analytical Applications opportunities for intelligent data connection are enabled through Business Intelligence with access to Online Analytical Processing tools. Integrated data stores allow for simplified standards compliance with enhanced security. These solutions fulfill stake-holders' needs for improved enterprise interoperability and usability while opening the door to expansive new opportunities in the hospital's future.

General Background

Institutional scope: The medical center is an integrated academic health facility with a $2 billion budget, including $145 million in federal research funding. The hospital's mission centers around education, patient care, and community outreach, with a strategic vision to rank among the top academic medical centers in the northeastern United States (University of Rochester 2008, University of Rochester Medical Center 2011b).

Financial data systems management: High national ratings require information technology excellence. Five years ago, the medical center in-vested in an enterprise-wide financial data management system (i.e., GE FlowCast). FlowCast provides basic patient information with financial specifics (e.g., ID, insurance coverage, admission/discharge status, and unit, as well as real-time census information).

Electronic medical records: Intended to run as a parallel platform, a new electronic medical records (EMR) system was officially rolled out at the medical center in March 2011. The federal-government mandated system contains information relevant to provision of patient care. The medical center chose eRecord's single point-of-access comprehensive EMR to optimize data

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integration and standardization within the platform. Institutional agility is supported, while departments continue to operate with locally responsive flexibility. (Epic Systems Corporation 2011, University of Rochester 2008, University of Rochester Medical Center 2011a).

Stakeholder requirements supporting local autonomy: Stakeholder groups have various functional needs of the hospital's two major operational systems. Financial managers need access to data relevant (and often particular) to their processes. Managers and other staff users review administrative operational data in near real-time (e.g., as workflow views), and require the capability to edit source systems. Both systems offer operational and master data with some overlap, but they maintain essential database and access autonomy. Each system has its own demanding process of data entry and editing that requires specialized knowledge to engage (University of Rochester 2008).

Stakeholder requirements supporting interoperability: Interdepartmental teams (e.g., financial case management, insurance verification, and social work) use both financial and clinical information. Senior managers need a smooth, integrated interface for views related to ongoing and timely decision-making. Whether reviewing relevant information directly from the database source or derivations of business intelligence processes, all of these stakeholders must have confidence that the data being presented originates from the source of record and is current.

Need for greater operational integration: Balanced against the medical center's mission and strategic vision, stakeholder requirements favor connecting the two systems with service-oriented components through a redesigned architecture that contains a basic infrastructure for integration. Loosely-coupled, services are interchangeable to serve a variety of needs. While the project's scope is cross-enterprise, flexibility for lines of business to use their own internal data remains an option (Godinez et al. 2010).

Functional integration orientation: Currently, there is no functional service connection between FlowCast and eRecord. An Enterprise Service Bus (ESB) messaging model is in place, originally designed with the intention to integrate the medical center's research infrastructure. The ESB might also serve as a foundation for more extensive enterprise-wide integration in the future (University of Rochester 2008).

Purpose of the study: This project analyzes the issues raised and makes recommendations for action. Throughout the study, TOGAF frame-work perspectives, terminology, and methodology are applied in order to arrive at solutions. A plan to approach implementation of a redesigned architecture is provided.

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Note: The parallel systems (i.e., FlowCast and eRecord) are refer-enced throughout this paper as lines of business (LOBs). The use of this phrase, defined as critical computer application systems vital to running an enterprise, is intended to highlight the systems' contrasting, yet parallel, functionality (SearchCIO.com 2000).

Introduction of Major Architectural Issues

Key Stakeholder Support
The hospital lacks adequate administrative support to coordinate autonomous line-of-business cooperation across the organization.

Knowledge-Sharing
Lines of business within the hospital have inadequate access to a full range of beneficial enterprise intelligence.

Systems Integration
Due to constraints imposed by vendor contract agreements, hospital information technology (IT) systems maintain their own databases and proprietary implementations which impede enterprise interoperability.

Standards Compliance
Workflow mandated to meet industry-standard compliance is in-efficient, involving levels of security and reliability risk because it is spread across multiple systems.

Framework Process
The frameworks that were chosen to facilitate the design and governance of existing side-by-side enterprise systems are unsuitable as an architectural approach to their integration.

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Analysis of Major Architecture Issues

Key Stakeholder Support

Business case: Senior management has coordinated major decision-making around the transformative *FlowCast* and *eRecord* architecture efforts over the last five years as an overarching priority. The systems are presently fulfilling operational goals. The separate LOB systems, fulfilling basically complementary functions, are currently considered by middle management to meet intermediate-term goals adequately. The hospital's concerted efforts to generate enthusiasm for the new IT initiatives have generally been successful, as stakeholders have experienced benefits through the systems' usability, availability, and interoperability.

The new systems provide standardizing infrastructures that serve as precedents for next-generation enterprise initiatives. The full support of key stakeholders is needed, however, to inspire organizational vision toward an enhanced architecture that features system integration. In particular, senior management involvement in planning and implementation is recognized as having a primary correlation to a new architecture's chances of success (Ross et al. 2006).

Baseline: At present, when major enterprise initiatives are being considered, the enterprise communications and public relations departments produce videos available over the intranet with promotional messages from hospital senior management such as the CEO, CIO, or CMO (Chief Medical Officer). The intranet homepage changes daily with inspiration messages, news, and policy updates. Through these venues, key stakeholders are able to communicate the value of architectural requirements such as interoper-ability at the enterprise level, but with limited effectiveness. The impersonal aspect of cross-enterprise communications doesn't reach broadly into domain-specific operational concerns.

Target: A formalized shared methodology is needed to inspire change. When more of the enterprise stakeholder community is engaged in problem analysis and collaborative solutions modeling, the way can be paved for the EA team to effectively bring them together around a shared vision.

Gap analysis: TOGAF ADM methodology from Preliminary Phase to Business Architecture serves to familiarize key stakeholders with the business process foundations of the proposal. With this knowledge, senior management move forward with approval of the project (Harrison 2009).

A lightweight front-line approach such as Coherency Management (CM) works to build on established hospital communication venues. Architects are provided access to a facilitation framework that helps coordinate communi-cation and collaboration between stakeholders. To augment the task of engaging, educating, and inspiring stakeholders, as well as serving to com-municate feedback to senior management, techniques to model various business processes help

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facilitators eliminate "semantic mismatch" ambi-guity that might exist across lines of business. Mismatch often happens between IT and physician leadership in their communications about medical center goals (Axelrod 2011, Gryning et al. 2010, Open Group 2009).

Diverse specialization, distribution of work locations, and departmental silos within hospital IT operations present challenges to communication.

CM promotes mutual awareness of the efforts (in some cases, the existence) of business units such as these across enterprise domain-specific operations, with the aim of creating trust and interest. Once a more personal foundation is established, greater levels of cooperation generally result. The EA effort can then proceed on a stronger footing, with senior management assuming the role of top-level consultants and communicators (Gryning et al. 2010).

EA framework: While Phase B business architecture is enabled through the proposed dialog and feedback, CM might allow greater transpa-rency of hospital operations and viewpoints to inform the implementation of Phase A. Stakeholders are identified, and their concerns and objectives clarified. Definition of business principles and goals is validated. Performance metrics (e.g., improved profitability or progress in coveted national rank-ings) might be defined. A vision is articulated, and with the success of the outreach effort, management commitment is reinforced (Open Group 2009).
Knowledge-Sharing

Business case: Even though collaborative opportunities for intelli-gence-sharing and innovation are central to the operational success of a major research-based medical center, LOB processes in the hospital have evolved in relative isolation to one another. Exacerbated by the autonomous function of their LOB information systems, the separate entities are often unaware of potential points of overlapping connection. As a consequence, knowledge-sharing accessible to key stakeholders that might yield col-laborative insight and innovation isn't being leveraged to fullest organiza-tional advantage.

Analytical business intelligence represents a paradigm shift in business process. Critical information is delivered with minimal intervention. Hospitals that make best use of enterprise business intelligence exhibit significant improvement in key performance criteria. Higher patient satisfaction scores and reduction in staff overtime are positively correlated with knowledge-sharing. Successful initiatives often see a reduction in adverse events per patient as well as unplanned readmissions, metrics that have a direct effect on national rankings tied to funding (Biere 2003, Hatch and Lock 2008).

Baseline: The medical center is currently fairly well-positioned for a basic level of academic knowledge-sharing through its dedicated research database and related services. Inpatient and Ambulatory EMR form a virtual suite of services connected to the research records databases (distributed both inside and outside the enterprise) as well as to services accessible through an investigator portal (University of Rochester 2008).

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There is little physical connectivity or logical interoperability, however, between the hospital's operational systems. The current information systems architecture connects general/patient accounting and Clinical Information Systems/electronic medical records (EMR) with their respective databases only. The only exception is a one-way feed that allows sharing of a limited range of basic patient information (University of Rochester 2008).

All three tiers of the enterprise system (i.e., client, server, and database) are connected, directly or indirectly, by the Enterprise Service Bus (ESB) messaging service (University of Rochester 2008).

Target: The hospital's disparate IT systems are brought together and enhanced through EIA Reference Architecture (EIARA) Data Warehousing and Identity Analytics Capability. Integrated business analysis reporting and discovery mining are enabled to make intelligent data connections vital to the medical center's reputation as a research facility. Equally important to competitive standing as a major hospital system are administrative operations informed by Business Intelligence (BI). New BI capabilities include formal patient/asset tracking procedures and real-time patient flow updating for improvement of patient care, as well as integration of clinical and patient record data with financial billing/claims systems data (see Systems Integration, pg. 11). EIARA's Search and Query Presentation Services are responsible for users' client-side capabilities (Godinez et al. 2010, Hatch and Lock 2008).

Gap analysis: In order to realize these beneficial enhancements to operational and research IT capability, the EIARA EII Component plays a critical basic role. EII extends a number of services that prepare information to be integrated for purposes of analysis by discovering information; ensuring high-quality data through extraction, cleaning, and harmonization; transforming heterogeneous data/information into a "single version of the truth"; and loading the processed data into a data warehouse. Interfaces provide a unified view of business and extend agile and reusable transfor-mation services, making BI accessible to applications, business process, and portals (Godinez et al. 2010).

The Analytical Applications Component provides a finer level of func-tionality to support business intelligence optimization and performance. Operational Intelligence Services provide responsive event-driven analytics on demand. Exploration and Analysis Services extend core functionality for Online Analytical Processing (OLAP) (i.e., processing multidimensional analy-tical queries), trend analysis and descriptive statistics critical to medical center enterprise decision-making. Data Warehouse Services act as founda-tion applications of BI services, and Cubing Services provide views for data retrieved from relational databases (Godinez et al. 2010, Wikipedia 2011c).

At the EIARA operating pattern level, Near-Real-Time Business Intelligence captures operational data on demand and transforms it for data warehouse storage. An Extract-Transform-Load (ETL) process splits the data into parallel subsets across processors, scaling for the volume needed to serve the hospital enterprise 24/7 (Godinez et al. 2010).

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EA framework: All requirements are driven by business process as defined and clarified in Phase B. As part of Phase A, key performance indicators related to business intelligence might include metrics balancing availability of insightful information across domains, with graduated query complexity against percent availability.

Following principles inherent to the Phase C process, application architecture knowledge-sharing capability is described in this EA as EIARA high-level, platform-independent categories. Outputs for this phase include Target Application Architecture mapped to relevant data architecture views (Harrison 2009).

Systems Integration

Business case: The two referenced systems (i.e., eRecord and Flowcast) are healthcare-industry standards in their respective areas of information management. Each extends their own proprietary vendor contract implementation and support agreements. Line-of-business data is maintained in separate databases. Application functionality is hidden behind simplified interfaces that render them essentially as black boxes.

System interoperability is thus constrained, with undesirable consequences for stakeholders across the enterprise without ready access to the data and information they need for operational performance. The information technology staff is unable to customize functionality at the interface level, precluding a viable revenue source for the organization. End users requiring a comprehensive information view of the patient/customer for capture or update are required to consolidate the information across several applications; these are accessed simultaneously or in sequence, with compromised efficiency.

Without IT architecture to make appropriately integrated information available, these conditions risk the hospital's ability to deliver high-quality service in a competitive timeframe. The bottom line is that health insurance companies approve payments based on improvement of financial and clinical performance metrics directly correlated to systems integration (Hatch and Lock 2008).

Baseline: The systems integration issue focuses on the particular application and data architectures involved in setting up the necessary physical connectivity and logical interoperability between the hospital's large-vendor operational systems for patient care (i.e., eRecord) and financial management (i.e., FlowCast). This issue is intrinsic to the develop-ment of knowledge-sharing capabilities. The two issues' baseline architec-tures are therefore the same.

Target: The goal is IT architecture that makes appropriately integrated information available to work with vendor-provided black box functionality. Primary applications driving this functionality fall into the high-level categories of metadata management and EII capability.

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Gap Analysis: Building on the ESB messaging backbone already in place in the hospital's IT architecture (see Appendix E), The EIARA Connective and Interoperability Services Component incorporates Enterprise Application Integration (EAI) as a middleware model. Systems are allowed to communicate through separated application and integration logic organized around business data and process. Standardized interfaces are used, provid-ing near real-time response. Through services contained in this component, operational systems are given access to analytical applications (see Knowl-edge-Sharing, pg. 7) as well as metadata management critical to integra-tion. For example, in patients' online EMR charts, physicians are able to access a trends view of key diagnostic and treatment indicators across the patient's entire medical history (Godinez et al. 2010, Wikipedia 2011b).

According to institutional and stakeholder information requirements, successful integration mandates versatile solutions. Data to be consumed must remain in place (i.e., large-vendor separate databases and well-established access systems) with enabled source updating. Views to aggregated/integrated information must be provided in near real-time to preserve optimal data currency. For example, financial case management submits Medicaid applications for inpatients as a service. Follow-up to the application process requires FlowCast access to patients' financial informa-tion, along with diagnostic information from eRecord, both ideally available in near real-time (Godinez et al. 2010).

On the operational level, the EIARA Data Integration and Aggregation Runtime Pattern describes the versatility needed to transparently manage the huge volume and diversity of data residing across the hospital's two major LOBs when brought together in the data warehouse. Extracts from the individual data sources are aggregated and normalized using integration logic, with results appearing as one unified virtual data source. The powerful underlying foundations of this pattern's processes of active integration are examined next: EII data preparation and metadata management (Godinez
et al. 2010).

EII has been described in terms of its beneficial relationship to Analytical Applications (see Knowledge-Sharing, pg. 7). The EIARA component's functionality has broad relevance to operational data integration as well.

Metadata plays a significant role in EII, beginning in the initial discovery stage in which the individual databases are analyzed for relationships and checked for integrity and accuracy. Business metadata communicate business rules, models, procedures, and performance management while providing contextual information (e.g., medical terminology used); technical metadata indicate data location and access details. Both are stored in a centralized metadata repository serving as an essential resource throughout the integration process (Godinez et al. 2010).

EII Profile Capabilities map data relationships across systems and integrate metadata with other processes into the metadata repository. Cleanse Capabilities quantify data quality in business terms. Requirements are standardized for individual data elements, with performance reporting to metadata for analysis. Finally, Transformation Capabilities manage aggrega-tions with conversion of reference data to assure consistency across systems (Godinez et al. 2010).

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Behind the scenes, the Metadata Management Component enables exchange and communication between systems using diverse data formats such as eRecord and FlowCast. Metadata facilitate collaboration between the systems' roles and tasks by actively documenting their relational and transactional backgrounds. End-to-End Metadata Management serves process optimization across the hospital enterprise by promoting standardization. Through its diverse palette of services, and to the extent that the hospital uses it wisely and creatively, metadata serve the function of an effective librarian for the enterprise. The purposes of integration are furthered by initiating and maintaining a complex network of metadata relationships (Godinez et al. 2010).

EA framework: Phase C encourages an abundance of views, viewpoints, and other artifacts to inform the design and understanding of IT systems architecture as related to business process. Modeling tools have the potential to go further, producing a rich associative metadata context as code-behind to applications and data structures (Axelrod 2011, Band 2011).
Standards Compliance

Business case: The enterprise mandates compliance with Diagnosis-Related Group (DRG), an industry-wide standard that ranks hospitals using data related to diagnoses, procedures, and demographics with controls for complications or comorbidities (Wikipedia 2011a). Results must be delivered in near real-time because they track and update current patient status. Compliance involves a complex operational workflow processed inefficiently in stages across the two systems (i.e., eRecord and FlowCast). These proprietary systems must be adapted to provide the appropriate units of workflow, and there may be functionality gaps between them.

Many risks are introduced with this process. Security is implemented through each system, creating two points of entry where one would be ideal. Multiple data-processing locations create possibilities for redundancy, com-pliance standard anomalies, and inaccuracy.
The most consequential productivity impact concerns Medicare re-imbursement. The hospital is paid per DRG "product" (i.e., related to each patient's diagnostic category) administered – considered to have a positive correlation with use of hospital resources. Inaccuracy in the compliance process manipulating these DRG numbers creates enormous risk to the hospital's bottom line (Wikipedia 2011a).

IT architecture to support integrated data aggregation with centralized security is needed for a more effective approach to standards compliance.

Baseline: Lack of integrated baseline applications and data architectures causes segmented workflow process in respect to DRG compliance. This unfortunate consequence fails to meet the needs of stakeholders and the interests of the enterprise as a whole.

Target: Data architecture to support effective EII capabilities addresses data quality before optimized data warehouse storage. Users access DRG process through standardized interfaces featuring simple single-point-of entry enhanced security.

Gap analysis: Comprehensive ETL data cleanup, enhancement, restructuring and summarizing are built into compliance EII capabilities, processes that constitute the data architecture's most

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resource-intensive services. Data quality issues are addressed as part of the data warehouse integration process (see Appendix C) (Brooks 2009, Godinez et al. 2010).

Serving the principles of Dynamic Data Warehousing, transformation can occur anywhere within the medical center's IT architecture as long as its processes are managed and governed. The end result is a unified view delivered to the user that actually represents a complex pool of data resources and services (Lahanas 2010).

Client-side presentation is included within the scope of EIARA's Presentation Services component. Database middleware connects warehouse servers to end-user client workstations. Hub servers interpret metadata in order to access data across multiple database servers for optimized speed and currency (Brooks 2009, Godinez et al. 2010).

EA framework: DRG process integration engages major data management principles central to Phase C Data Architecture. A clear understanding of how the data is used to meet compliance standards influences plans for functional design of data warehouse layers to optimize storage, transport, and reporting. Incorporating the most aggressive security standards, the chosen data architecture is capable of handling the complex mix of data transformations required by applications implementing multiple compliance stages (Brooks 2009, Harrison 2009).

Framework Process

Business case: The vision and business architecture behind the new electronic records system are motivated by a strategic vision that establishes patient service as a priority. The medical center's commitment to standard-ized data and practices is central to its process, inspiring deployment of single-point-of-entry access to clinical information systems. Integration of as many stand-alone clinical systems as possible is prioritized as part of the eRecord EA effort (University of Rochester 2008).

In the process, the University's Information Technology Strategic Plan has deemed the "back-office" applications, including patient accounting's FlowCast, to be supported well enough without further integration with other systems (2008). In the five years since the Plan was released, how-ever, stakeholder requirements have thrown this evaluation into question. Real-time data views integrating patients' clinical and financial information (e.g., related to financial counseling, case management, or social work) are required in the course of common hospital operations, and ad hoc mitiga-tions initiated by end users or developers are time-consuming and costly. The need for intermediary processes violates the nonfunctional system requirements of interoperability, usability, maintainability, availability, security, and reusability. Without a structured enterprise architectural pro-cess to address this critical area of dysfunction, stakeholders' unmet needs for integrated information perpetuate the current misalignment of business process with IT architecture.

Baseline: In spite of the short period that has elapsed since the introduction of electronic medical records in March, there is strong evidence supporting the need for integration of

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eRecord patient information with existing FlowCast financial management functionality. Currently, no formalized EA is in process.

Target: In order to fully support and automate the hospital's core capability of interoperable integration, the enterprise architecture initiative demonstrates value by making the two existing platforms' delivery cheaper, faster, and more likely to succeed. Communication and understanding between stakeholders are facilitated, avoiding duplication of effort (Ross et al. 2006, Godinez et al. 2010, Tamm et al. 2011).

An enterprise-wide integration EA initiative moves the hospital's existing Information Architecture (IA) toward a more fully actualized EIARA model. In the process, business context is applied to a common language and solution-design foundation with support for metadata-enabled and analytical intelligence opportunities (Godinez et al. 2010).

Gap Analysis: At the highest level, enterprise maturity models are studied and the hospital's goals assessed. Stakeholder consensus on the need for evolution from basic information interaction (i.e., EIA's Developing stage) to an information-enabled stage of business innovation (i.e., Optimizing) is negotiated and objectives clarified (Godinez et al. 2010).

Human factors analysis to identify knowledge, information, and data requirements comes next in the form of architectural visioning. Business scenario workshops are held, with questions asked and key performance indicators surveyed to determine the need for systems integration (e.g., "What percentage of production time do users spend looking for the information they need?" or "Which stakeholders – or systems – are most affected?") (Godinez et al. 2010, Harrison 2009, Smith 2008)

Phases to develop and align architectures (i.e., business, information systems, and technology) proceed with framework guidance from the ADM. Information technology architecture is designed within the constructs of the EIARA to include (from high- to low-level): components – comprised of capabilities – mapped to conceptual operating models (Godinez et al. 2010, Open Group 2009).

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Solutions

Key Stakeholder Support

Recommendations: Education of key administrative staff regarding enterprise needs for LOB integration is an essential first step to securing their support. Participation in business scenarios to define outcomes and actors, and ADM Preliminary Phase process agreement regarding scope, principles, and governance of the project, follow. The areas of concern are explored to the point of Phase A architectural vision and Phase B business process relationship definition (Harrison 2009).

Coherency Management (described in Analysis of Major Architecture Issues) establishes communication and collaboration with the wider stakeholder community. With a full range of input and feedback, the EA effort can proceed on a stronger footing, with senior management assuming the role of top-level communicators and consultants (Gryning et al. 2010).

Alternative considered: Thompson describes her Stakeholder Analysis and Planning technique used to solicit stakeholder consent. There is peripheral overlap with the ADM process as far as emphasis on stakeholder education, enterprise communication, and participation in framing goals, but the design is anecdotal in format with little formal structure.
Although it entails a greater commitment of time and resources, the recommended combination of TOGAF and Coherency Management as an approach provides frameworks that provide a clear focus on relevant business process, prin-ciples, and the enterprise environment (Harrison 2009, Thompson 2011).

Knowledge-Sharing

Recommendations. To meet requirements for metadata-informed business intelligence with EII support as described in *Analysis of Major Architecture Issues*, *MediSolv* provides Analytical Applications OLAP support to integrate clinical and financial data. The Metadata Coalition (MDC) *Open Information Model* (an open-source metadata management repository) is recommended for metadata management. MDC is broadly based on UML, SQL, and XML and is technology-independent, designed to facilitate sharing and reuse in various database and data warehouse domains. *Speedminer* software extracts data from the hospital information system to incorporate tools such as KPIs and dashboards that are accessed by users via web browser (MediSolv Healthcare Business Intelligence 2010, Singh 2011, Subrahmanya et al. 2010).

Alternative considered. Microsoft Excel is widely used throughout the hospital by users creating ad hoc business intelligence spreadsheets for common operational decisions. Retaining these systems as alternatives to business intelligence is considered because of their current ubiquity; their uncontrolled shared quality, however, severely compromises data quality and consistency. In a heavily regulated industry such as healthcare, the overall risk involved is unacceptable (Quinn 2007).

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Systems Integration

Recommendations. Service-based architecture provides the interconnection required to achieve enterprise interoperability through systems integration. TOGAF's Integrated Information Infrastructure Ref-erence Model (III-RM) serves as a high-level planning reference. The III-RM provides a taxonomy describing the necessary components to align data, applications, and technology related to integration (Harrison 2009).

Starting from the ESB messaging service connecting the whole of the hospital IT infrastructure, an enterprise data warehouse is connected simultaneously to financial databases and the EMR database suite. The warehouse communicates with Research EMR components as well. Business intelligence applications are accessed by the aggregated warehouse data through OLAP tools. For full component descriptions, see *Analysis of Major Architecture Issues* (University of Rochester 2008).

Alternative considered. Event Stream Processor (ESP) is a scalable, responsive alternative to data warehouse data aggregation using ETL. With a query language similar to SQL, ESP analyzes streams of events as changes occur in real time.

The large volume of data generated and consumed by the hospital enterprise makes scalability an attractive option. Real-time processing pre-sents data currency advantages. Lack of ability to create historical views is the ESP solution's critical drawback, however. An expensive framework for capturing and retrieving data is necessary, which would not be feasible for the amount of data being processed in a hospital environment (Drobi 2008).

Standards Compliance

Recommendations. EII provides comprehensive cleanup, enhance-ment, restructuring, and summarizing of ETL data (see *Analysis of Major Architecture Issues*). In frequent incremental extracts, dynamic centralized data warehousing applications combine financial and clinical data from the two databases (as well as other hospital sources). The aggregated data serve as source material for reporting, business intelligence, or analysis.

If large queries or complex operations are run against the data, a shadow server is used to avoid placing excessive load on the data warehouse (DW).

To extend functionality, commercial-off-the-shelf (COTS) products are available that create tailored ETL programs. Custom applications providing integrative capability between the two systems (and filling gaps in function-ality of either one) are also developed in-house. As the architecture matures, vendor updates to the primary systems might be developed to replace these agile ad hoc solutions (Brooks 2009).

Alternatives considered. A unified interface presented to the user that sits on top of heterogeneous systems would be ideal. A single security implementation might be presented. This solution isn't feasible, however, as the primary systems are vendor-owned, and interfaces on top of their products are not supported.

After the centralized DW functionality is well-established, an option is being considered that might improve system extensibility in the future. The DW might be upgraded from a single data-storage facility to a two-tiered capability: a central DW

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extending to multiple decentralized data marts. Similar to the central DW, each satellite takes care of its own data aggregation and integrative capabilities for its location to provide "one-stop-shopping" (Brooks 2009).

Framework Process

Recommendations. The particular requirements of operational systems integration mandate a dedicated architectural initiative. TOGAF's ADM, with support from its Enterprise Continuum, provides a comprehensive framework with structured methodology. Business process is aligned with IT, while stakeholder participation is actively engaged.

Information systems and technological capabilities to be included in the new architecture are chosen with reference to TOGAF's III-RM Common Systems Architecture. The III-RM helps facilitate alignment with the require-ments of the medical center's primary communication venue, its intranet web portal.

Alternative considered. The Zachman Framework provides a rudimentary architecture framework as well as a taxonomy for artifacts (similar to the TOGAF Technical Reference Model). These features serve as
a strong foundation for EA in that they reference business process and requirements. TOGAF and the ADM provide more in the way of a method-ology to collect, analyze, and manage information in a prescriptive context useful to multiple domains and viewpoints (Wikipedia 2011d).

Roadmap
Two-Year Plan
(each phase four months)

Phase 1

- Conduct business scenarios for key stakeholders
- Develop ADM Phase A vision
- Obtain high-level management approval for project
- Complete Phase B

Phase 2

- Conduct Coherency Management project
- Complete ADM Phase C-E

Phase 3

- Negotiate ADM Phase G Governance
- Complete Coherency Management project
- Senior management begins ongoing communication/consultation role
- Negotiate contracts with BI software providers
- Develop DW application
- Develop standards compliance application
- Buy COTS standards compliance (optional)
- Develop EII, OLAP capability

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- Develop Business metadata
- Plan metadata management processes
- Plan III-RM Network Services
- Consult with security (regarding integration)

Phase 4

- Plan ADM Phase F Migration
- Begin population of TOGAF Enterprise Repositories
- Continue standards compliance application development
- Develop technical metadata

Phase 5

- Continue population of TOGAF Enterprise Repositories
- Test application/network/hardware
- Develop metadata management
- Design user interface applications (integration-related)

Phase 6

- Implement ADM Phase F Migration Plan (data transfer)
- Implement ADM Phase H Change Management
- Continue population of TOGAF Enterprise Repositories
- Complete application/network/hardware testing
- Re-evaluate two-tier DW upgrade plan

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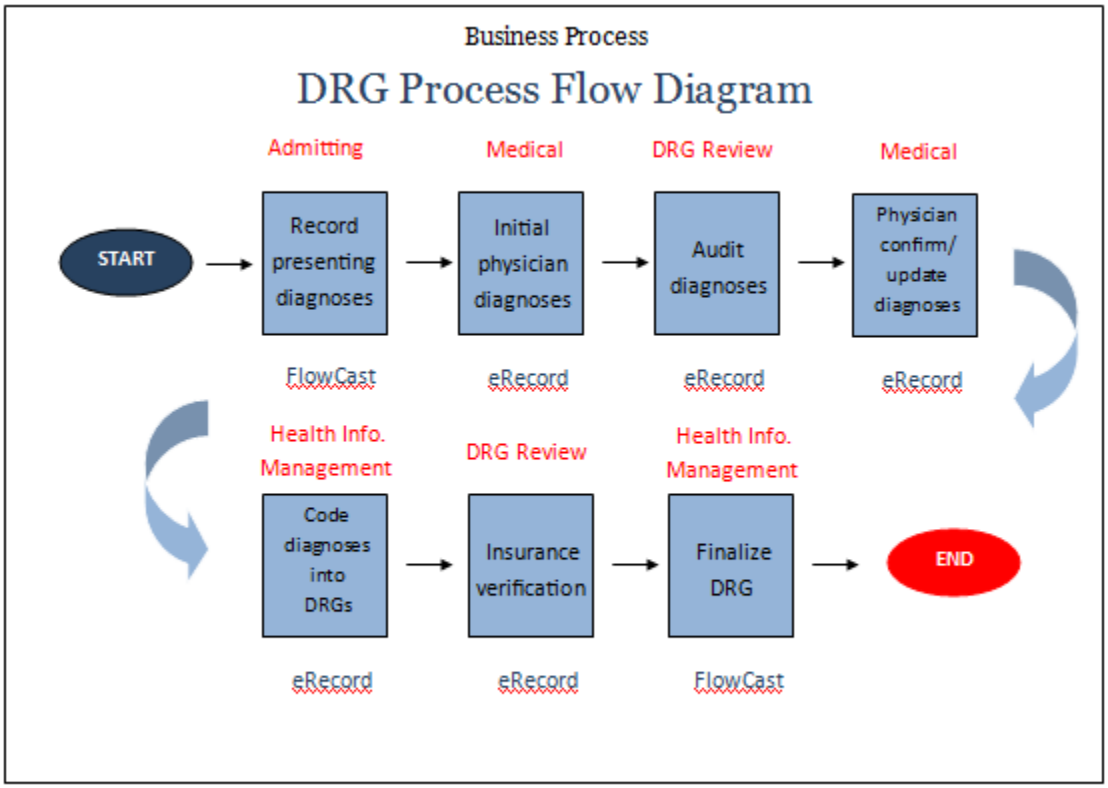
Appendix A



(Open Group 2009)

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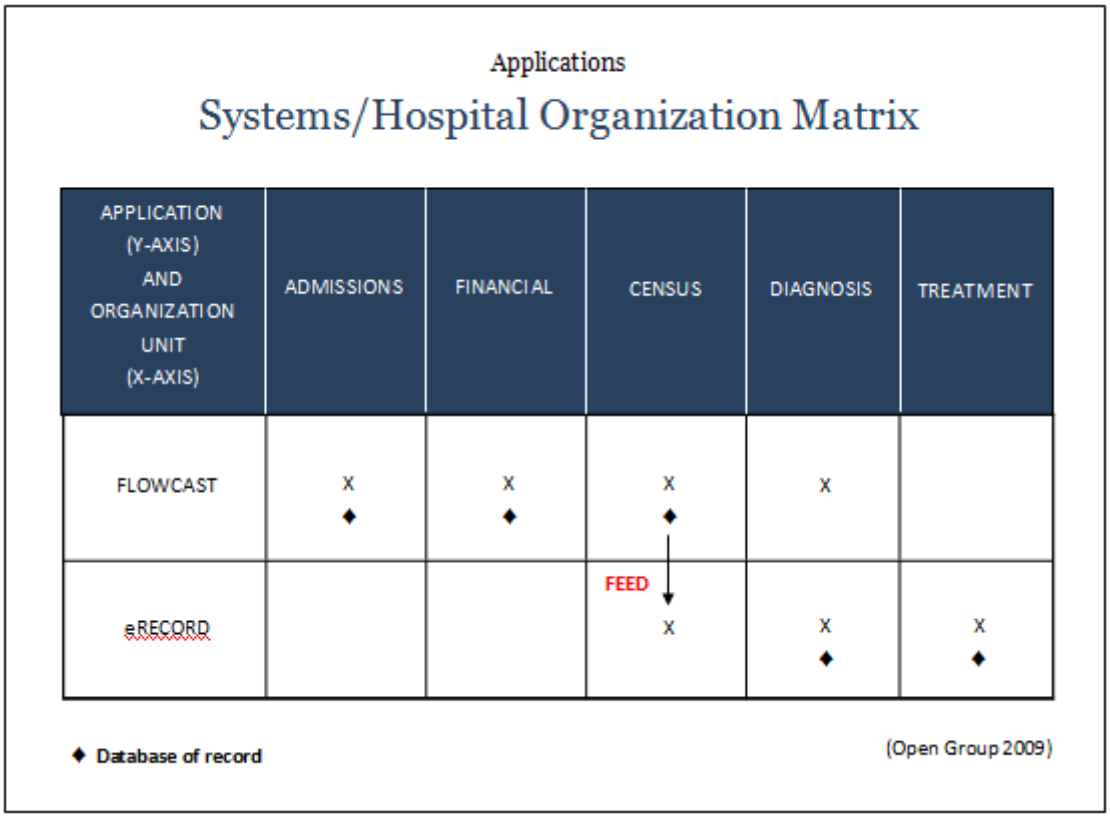
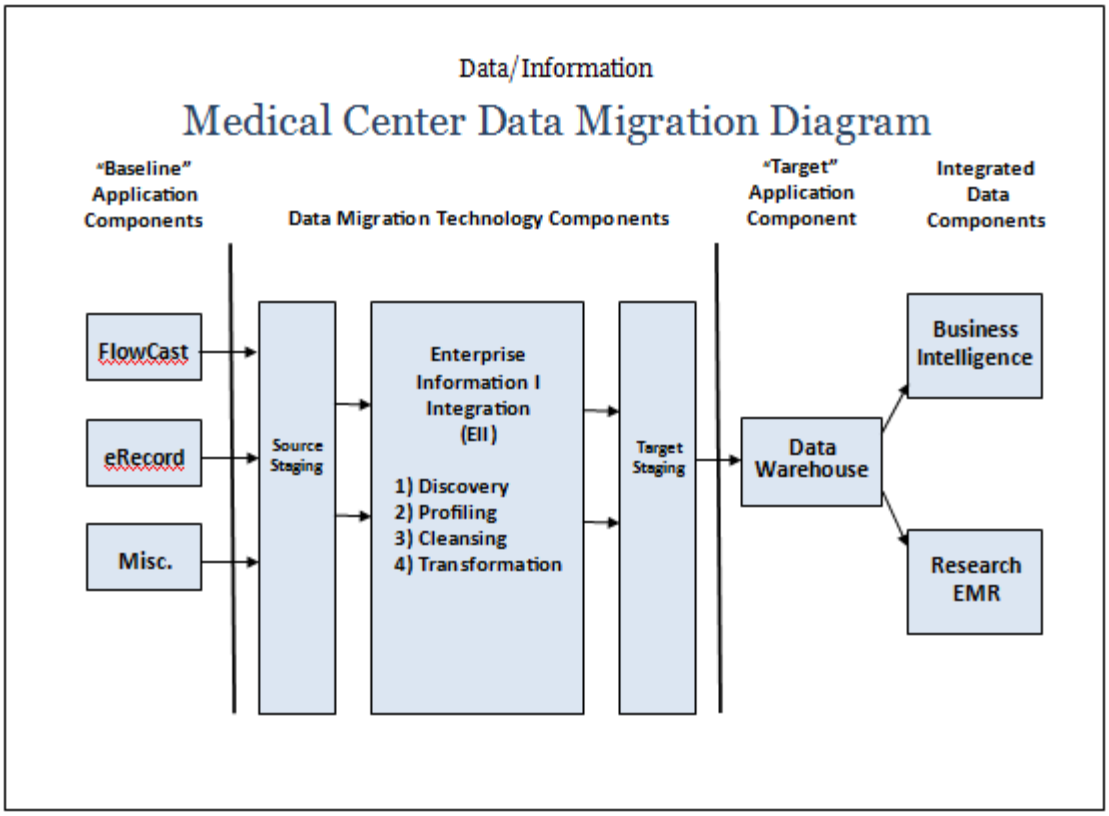
Appendix B



[1] Names of organization, specific divisions, and employee names are kept confidential out of respect for NDA with the client.

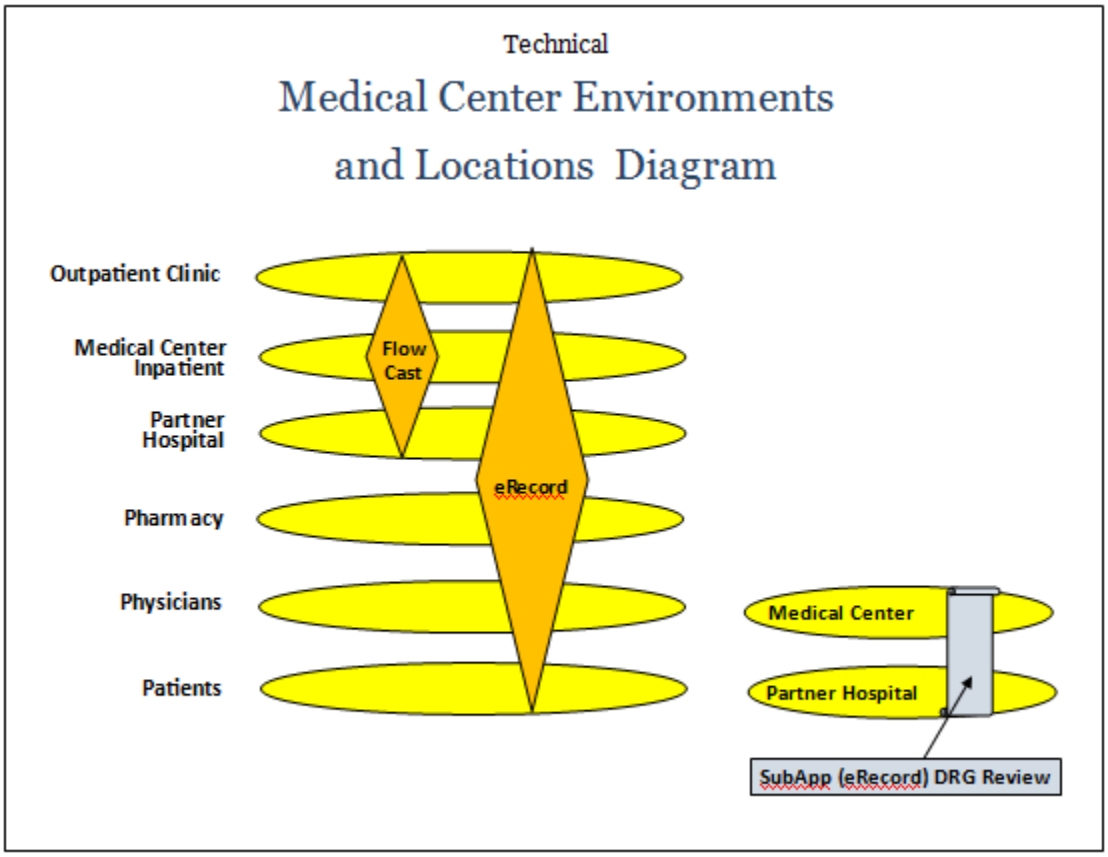
Appendix C



(Open Group 2009)

[1] Names of organization, specific divisions, and employee names are kept confidential out of respect for NDA with the client.

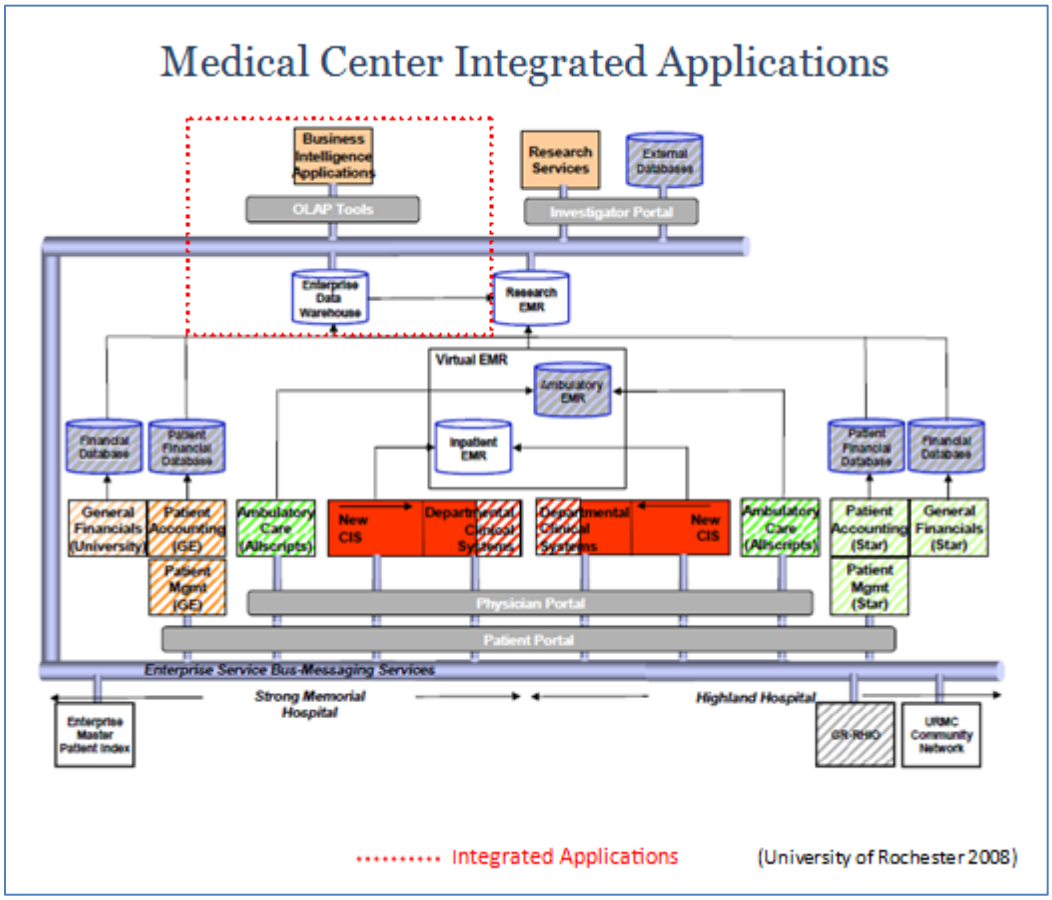
Appendix D



(Open Group 2009)

[1] Names of organization, specific divisions, and employee names are kept confidential out of respect for NDA with the client.

Appendix E



[1] Names of organization, specific divisions, and employee names are kept confidential out of respect for NDA with the client.

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AUTHOR'S BIO

Elizabeth Peacock is currently working as a programmer/analyst with Frontier Communications in Rochester, NY. She designs and implements intranet applications for corporate systems. She enjoys making the user experience as multi-faceted and enriching as it is functional.

Earning a graduate degree in Web Design/Software Development, Elizabeth attended one of Dr. Else's Enterprise Architecture courses as part of her graduate coursework. The knowledge gained has informed her understanding of the ways a large corporation works, allowing for a more involved participation and creative perspective.

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