Healthcare Interoperability through Enterprise Architecture

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ABSTRACT
Current Enterprise Architecture (EA) models provide little guidance, if any, for implementing interoperability in healthcare organizations. We propose an EA interoperability method that leverages current EA models and business IT. This phased approach was followed during the implementation of an Integrating Healthcare Enterprise (IHE) profile. IHE Profiles provide a common language for purchasers and vendors to discuss the integration needs of healthcare sites and the integration capabilities of healthcare IT products. This profile was reviewed and approved by member organizations of the IHE and is currently being used in trial implementation. Our EA interoperability method refocuses a healthcare organization's principles and IT to include external entities that current EA models ignore for competitive reasons. Our approach shows the advantage of considering these external relationships between competitors and synergistic third parties. Advantages include increased patient satisfaction, meaningful data exchange and integrated transport solutions that support high-level business processes.

Categories and Subject Descriptors
H.5.3 [**Information Interfaces and Presentation**]: Group and Organization Interfaces – *evaluation/methodology, organizational design, theory and models.*

General Terms
Management, Design, Standardization, Theory.

Keywords
Enterprise architecture, electronic medical records, electronic health record, hospital IT management, health information technology, interoperability

1 INTRODUCTION
Enterprise Architecture (EA) is the act of organizing logical flow between applications, data and infrastructure technologies, as captured in policies and technical choices which represent the organization's business principles and practices throughout all projects [1]. Architecture can be viewed as a blueprint for the optimal and target-conformant placement of resources in the IT environment to support business function [2]. EA is a comprehensive description of all of the key elements and relationships that make up an organization [3]. EA is used to define alignment of an organization's mission, goals, and objectives within the information system [4]. Simply put EA is integrated IT supporting business in every way. Many organizations have employed EA frameworks in order to improve integration; however, most of these companies are commercial in nature. The steps taken when implementing an EA methodology have the ability to improve understanding of healthcare functions and show better alignment with IT and business architecture [5]. The acceptance of an EA approach in healthcare has been slow due to the complex nature of the environment and the severity of any one single error as it could relate to poor patient outcome. Interoperability binds together real-time, life-critical data that will transform the way we provide healthcare [6]. Without an EA based development of business resources or systems, the results could include duplication, failure to integrate, poor information exchange and ineffective technology support. All which can result in high patient morbidity [1].

HL7, ONC, ICD-10, SNOMED-CT and various other standards development organizations have authored many standards in healthcare information technology (HIT). Hospitals face the challenge of incorporating these standards into their existing systems. Many of them need to reengineer and start from the beginning. Utilizing existing EA frameworks is definitely advantageous to these organizations.

Shared services are an integral part of patient management within a hospital. Multiple departments such as ambulatory, surgical and emergency medicine utilize core services of the hospital such as laboratory, physical therapy and even environmental services [7]. Sharing these services outside the organization is yet another step of complexity. EA methodologies attempt to align IT with business goals. In doing so, interoperability must take into account the functions of other organizations' applications that may ultimately compete with the business. However such interoperability can be beneficial and even legally required. Organizations must consider interoperability when challenged to integrate their system with others. [8].

Interoperability with other EA frameworks was not a primary concern for many existing EA frameworks. However, there are a few health systems that have employed such EA strategy - interoperability. VistA is one example of such technology

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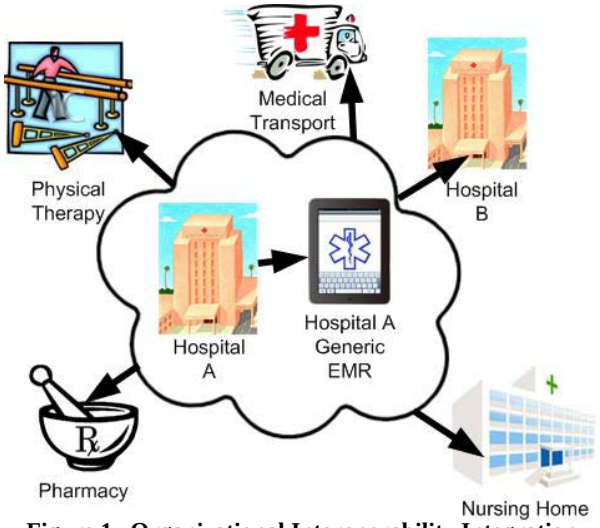

Figure 1. Organizational Interoperability Integration

architecture that has been deployed by UC Davis and Texas Tech. It is interoperable and was built with interoperability in mind. Another example is the Veterans Health Information System and Technology Architecture which has EHR, administrative and data processing capabilities. It has proven excellent among governmental agencies, but those two non-governmental institutions mentioned above lacks the ability to share information. We looked at four major EA processes, showed where they lack interoperability, and propose how to incorporate interoperability into EA frameworks using a step by step phased approach.

2 WHAT IS INTEROPERABILITY

Interoperability defined by HL7 [9] has three parts: Technical, Semantic and Process. Technical interoperability focuses on the physical transmission of messages containing health data and the security of such transport. Semantic interoperability focuses on the relevance of the transmitted information to both organizations. If an organization sends data that is relevant to them, but has no meaning for the recipient, then it is not interoperable. Process interoperability concentrates on higher-order workflow that makes the shared data experience valuable [8]. Reverse engineering the process, this type of interoperability shows how the shared data can support the specific activities of the organization and how to integrate the data into their current system. Figure 1 shows how interoperability affects a single organization. The organization needs to be able to produce data that is useful to other organizations as well. The data, termed generic in Figure 1, is presented in a format that can be effectively used and integrated into other organizations. Many organizations are still struggling with the integration, tackling more involved steps only to bring even more confusion.

3 ENTERPRISE ARCHITECTURE FRAMEWORK

There are various EA framework models available today. The Open Group Architecture Framework (TOGAF) provides a high level and holistic approach to design EA, which is typically modeled at four architectures: Business, Data, Application, and Technology [10]. Federal Enterprise Architecture Framework (FEAF) provides a common methodology for IT acquisition, use, and disposal in the Federal government [11]. The Zachman Framework consists of a two dimensional classification matrix based on the intersection of six communication questions (What, Where, When, Why, Who and How) with six rows according to reification transformations [12]. It is the oldest and original EA model. The Gartner EA Process Model is a multiphase, iterative and nonlinear model, focused on EA process development, evolution and migration, and governance, organizational and management sub-processes [13]. The above EA models do an excellent job of integrating business functions, objectives and goals with IT, but most do a poor job of supporting interoperability with outside organizations. For our study, we consider interoperability issues between organizations, not within; however, it should be noted that establishing intra-organizational interoperability is a high priority that should be accomplished while implementing any EA model.

Gartner states that architecture is a verb, not a noun. Interoperability falls into this distinction. This means that interoperability is an ongoing solution, not a onetime patch. Most EA models do not deal with third-party interactions. Consequently, core interoperability-related information is not captured [14].

3.1 *TOGAF Interoperability*

The first mention of interoperability in TOGAF is during the Business Architecture (Phase B). The Business Information Interoperability Matrix lists stakeholders across the organization and their requirements of systems within the organization. This is refined within the Information Systems Architecture by showing specific systems and keeping in accordance with the enterprise technical standards. There can be no interoperability conflicts among the matrix due to potential for reusability; however, given the underlying business flow inherited in each system, re-use might require more work than feasible. During Rome 2010 TOGAF acknowledged the need for an interoperability artifact. Figure 2 shows a comprehensive approach of adding interoperability that will be part of each phase. The Semantic Interoperability Workgroup has been formed and is working towards a solution, but there is no official publication.

3.2 *FEA Interoperability*

There are many unique characteristics that describe federal architecture that separates it from commercial counterparts [15]. Among other things, politics is the most demanding difference. Incorporating interoperability means baking it in, not icing it on. Attempting to do this with such a large and complex structure is daunting. The National Information Exchange Model (NIEM) attempts to leverage the FEA Data Reference Model to prevent

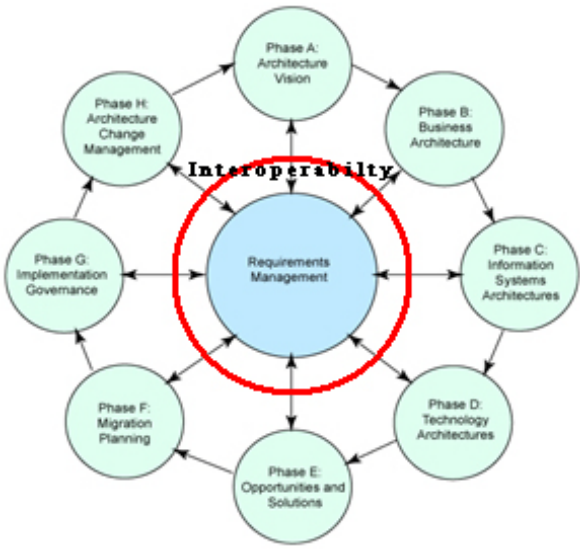

Figure 2. TOGAF Interoperability Element Encompasses All Aspects of TOGAF Methodology

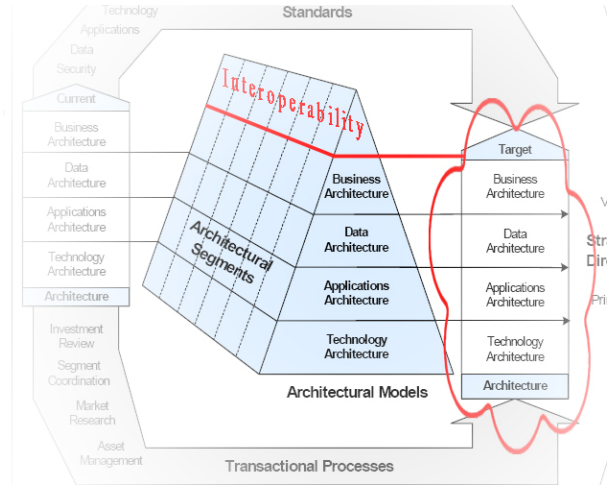

Figure 3. FEA Interoperability Solution

fragmentation and a lack of semantic interoperability. Figure 3 shows where interoperability needs to be created as its own beginning architectural segment, but then encompass all the work products from implementing FEA.

3.3 *Zachman Interoperability*

The Zachman Framework, originally Information Systems Architecture Framework was conceived by John Zachman in 1982 and publicized in 1987. The Zachman framework states that the same complex thing or item can be described for different purposes in different ways using different types of descriptions (e.g., textual, graphical) [12]. According to Zachman [16], it may not be possible to implement fundamental change once the infrastructure is in place, it may be necessary to start from the beginning. Middleware can be used to reconcile two heterogeneous and discontinuous systems. An EMR and Pharmacy system could provide a lot of information to support each other, but if middleware is used as a patch between the systems, perhaps only prescriptions get transmitted. This could impact patient safety if the pharmacy has information regarding previously prescribed medications that may interact with the current prescription. This patch approach could reduce flexibility, since heterogeneous means you optimize the parts at the expense of the whole and interoperability means you optimize the whole at the expense of the parts [16]. The Zachman Framework does not address interoperability of any kind, except to state that it must be included in the original architecture design. We propose the connection in the gap between business location and role as shown in Figure 4. By examining external locations and their connections, we'd like to implement interoperability.

3.4 *Gartner Interoperability*

The Gartner process for EA brings together three constituents: business owners, information specialists and the technology implementers. The focus is on where the organization is headed, not where it has been or is currently. Once the goal is determined, the current resources, along with others, can be leveraged to achieve that goal. Since Gartner is a consulting firm they are most in the position to integrate interoperability from the beginning of the EA plan.

4 THE FIRST EA INTEROPERABILITY PHASE

Technical interoperability progress has been remarkable with many mature solutions, but getting organizations to change their workflow to accept a universal data element that will have impact across multiple organizations is difficult. Integrating the Healthcare Enterprise (IHE) profiles can create interoperability through the exploitation of HL7 ADT messages, commonly used inside an enterprise system, to communicate with an outside resource utilizing SOAP HTTP approach to uniquely identify each resource as completed in the ebXML Registry Information Model version 3 [17]. EA focuses on aligning IT with every aspect of business functions, goals and practices. EA can help increase your profit margins by effectively using IT to streamline business process. With this self-centered goal, it's hard to work the goals of other organizations, even competitors, into the bottom line. A hospital does not merely treat a patient; it provides a full service experience. There are multiple services available to the patient and other care givers. Knowing who these stakeholders are and asking what can be done to keep them satisfied is absolutely necessary. The same outside the box thinking needs to be done during the initial phase of an EA endeavor.

4.1 *Establishing External Stakeholders*

External stakeholders need to be assessed when establishing stakeholders. These are the ones that stand to gain an advantage from the information we will share and those whose information we want to use. We stand to gain far more from this relationship. First, the customer will appreciate our ability to create a seamless relationship with an organization that might also provide service, sometimes the same service. Our results demonstrate a better understanding of the global business process when external stakeholders are established. During the initial IHE profile phase external stakeholders were left out and it was only then we realized that smaller hospitals might require document sharing using less technical methods, such as by email or portable media. So we stand to gain a lot by thinking outside the box and including external stakeholders in our list as shown in Figure 5.

4.2 *Determine Architectural Interoperability Constraints*

It is necessary to analyze the business principles of your stakeholders identified in section A. If your institution typically works on a team based approach to medicine and your outlying facilities are staffed with single clinicians due to budget constraints, then you can't assume a single practitioner will be an expert on all differentials produced by a clinical team consisting of anesthesiologists, pathologists, neurologists and critical care medicine. Recognizing this and many other constraints are crucial if one of you end goals is to be able to share semantic information

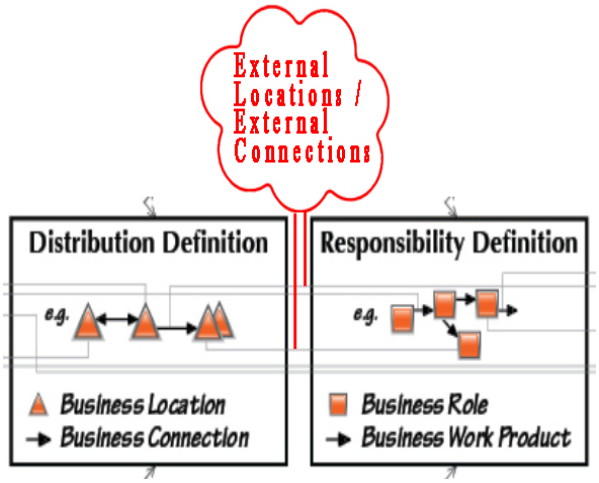

Figure 4. Zachman Interoperability Insert from Zachman Framework [20]

Stakeholder	Involvement	Class	Relevant Artifacts
Outlying Medical Center	Receiving results, medical summaries, discharges	Keep Satisfied	Organization Chart Business Footprint Goal/Objective/Service Model Application Communication
Pharmacy	Receive Rx, Receive Rx Reconciliation	Keep Satisfied	Application Communication Goal/Objective/Service Model
Rehab	Receive Orders, Discharge Summaries	Keep Satisfied	Organization Chart Business Footprint Goal/Objective/Service Model Application Communication
Primary Care Provider	Receiving updated medical summaries	Keep Informed	Goal/Objective/Service Model Communication

Figure 5. Sample External Stakeholder Map Matrix

with those external entities. A sample architectural principle of an external pharmacy stakeholder is shown in Figure 6. These principles need to cover major realms including Business, Data, Application and Technology architectures.

4.3 *Determine Architectural Interoperability Process*

We have used four frameworks to show the lack of interoperability, this does not mean they are a poor choice for EA methods. The four described frameworks are the top four frameworks in use today.

The choices made as part of those frameworks' process need to accommodate interoperability. A new question needs to be asked when making any future decision: How can we accommodate our external stakeholders in this process or what can we do to insure interoperability? The term should become part of the common vernacular across all systems. We identified a number of points for insuring interoperability through the organization in the IHE profile:

- Project lifecycle
- Handover processes
- Management processes
- Procurement processes
- Portfolio management processes
- External processes

The final process listed is paramount to insuring interoperability throughout the organization. If ignored, the entire interoperable piece will fail. The interoperability map show in Figure 7 will highlights the required focus areas.

Principle: Reconciliation
Statement: Medicines and Allergies must be reconciled before prescribed orders.
Rationale: As pharmacy availability increases, number of medications increase, mobility increases, and multiple provider interactions increase the need to ensure that new prescriptions do not conflict with current prescriptions and patient allergies are considered when prescribing is paramount. Additional steps must be taken to ensure adequate substitutions in cases where the above conflicts occur and the resulting substitution provides the expected outcome.
Implications: Prescriptions must be filled and recognition that the above conflicts can occur, will require additional screening and clinical decision support systems to be in place in multiple locations with ultimate pharmacist discretion, prior to prescribing and dosing medications.
Applications must be assess for ability to accurately reconcile medications and allergies according to current recommendations and provide unofficial results for pharmacist approval.
Recoverability, redundancy, and maintainability should be addressed at the time of design.

Figure 6. Architectural Interoperability Principle

4.4 *Determine Architectural Interoperability Budgets*

Budgets were not part of our research, but it's justified to mention collaborative efforts and funding on behalf of both the organization and external stakeholders. When approaching external stakeholders, the relationship that is going to be formed is not merely an operational one, but perhaps a financial one as well. Consider cost sharing when developing an architectural solution that will benefit the external stakeholder as well.

5 THE SECOND EA INTEROPERABILITY PHASE

Interoperability must be considered from the beginning, the first phase is the most crucial to any EA method. If the stakeholders, principles, processes, budgets, constraints, terminology, project champions, governance and tools are not well thought out and defined, the project will lack interoperability, which is crucial in healthcare. The second phase shows where an organization can implement interoperable solutions. Defining specific goals, business layers and determining where the organization needs to develop new building blocks is essential.

5.1 *Determine Interoperability Goals*

If you only know what you want, then you aren't going to get what you need. Gartner believes that you must start with where the organization is going, not where it currently is [18]. This does not refer to reusability and duplication of processes already completed, but rather focusing on what you need to achieve. Our

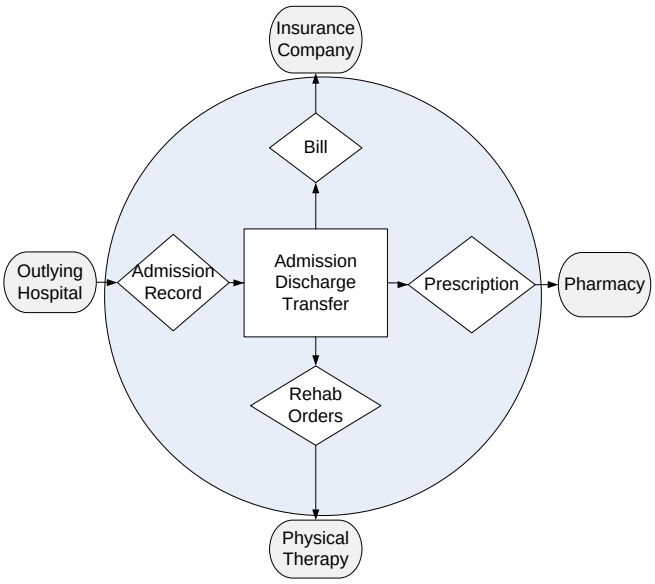

Figure 7. Interoperability Map

interoperability goals should not be clouded by what we can currently do, but rather what we will need to do in the future regardless of impact. To that extent we need to model a variety of external functions that stem from internal operations. Dynamic thought process is necessary to infer external functions that might appear to have an external impetus. For example a patient being transferred from an outlying hospital to your organization, might be recorded as an external impetus, but realize the existence of some specializes service, known practitioner, accepted insurance or some other reason is making the patient transfer to your hospital. Identifying these internal resources as external impetus is challenging, but required. A business footprint diagram shows very little external operations. We need to examine another layer.

5.2 *The Interoperability Layer*

We can continue to decompose the business footprint by adding an interoperability layer shown in Figure 8. This layer shows the relationship between business services and integral external entities. There are many points of integration inside a hospital, just as many points for interoperability outside the hospital. Hospitals might contract unique work to third party vendors, such as radiology services. External Resources need to be able to interoperate with the organizations. This is the same with specialties. It becomes visually clear how important interoperability is to a healthcare organization and others as well. Figure 8 demonstrates the additional work necessary to insure that the business footprint extends beyond its physical location. The red shaded areas and lines show additional steps take to account for an interoperability layer. Since information is shared among external entities so often, it is pertinent to rethink business strategy with external stakeholders in mind.

5.3 *Gap Analysis*

Every framework suggests doing a gap analysis; this is the clear cut way of showing where we need to create new building blocks. No framework talks about the gap between organizations. A gap analysis needs to include the infrastructure needed to share information with external entities. Some of this infrastructure may be in place, but additional measures will need to be taken to enable interoperability. Current healthcare systems are have been producing paper records for many years, but have now been given a target for sharing electronic media within the next few years. The US government's meaningful use initiatives, the European Union's 2011/24EU directive and Australia's HealthConnect are all examples of where the systems need to be and our research shows how interoperability can be implemented.

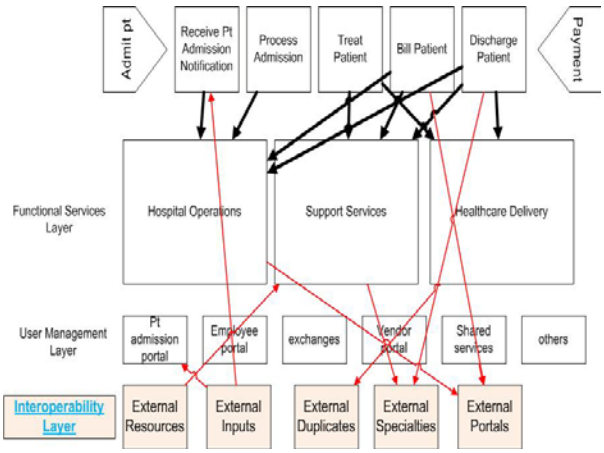

Figure 8. Interoperability Layer

6 THE FINAL EA INTEROPERABILITY PHASE

Incorporating the above steps into existing EA methodologies places an organization on the track to integrated interoperability of all three types. Many existing IHE profiles will aid in specific interoperability solutions and help integrate into existing processes. These profiles can act as implementation guides for specific work products. The current Transport Record Summary (TRS) Profiles slated for trial implementation explains how an organization might organize their data for all types of medical transports. This profile leverages current standards such as HL7 and LOINC to implement interoperability for common hospital practices. They show how content is created and consumed. The content agent accesses clinical information in structured and non-structured form and provides a method for a clinician to update the current data. It authenticates the clinician prior to storage of additional information data which might be combined with other authentication processes used to finalize the record [19].

The creation of a National Health Information Network (NHIN) and a local Health Information Exchange (HIE) assist healthcare organizations in data exchange. These established infrastructures provide the systems necessary to enable technical interoperability. Record Locators Systems and cross community queries obtain XML versions of patient EHRs and other patient data. Organizations need to incorporate XML processing as part of an EA work product. The Continuity of Care Document (CCD) is an XML based specification for clinical document exchange. Healthcare organizations that structure their IT system to produce CCD records are able to levy the transport support systems in place.

7 TRIAL WORK

The EA interoperability process was used when developing the IHE supplement profile mentioned above. The profile was developed during the 2011/2012 work cycle of the IHE. Initial face to face meetings occurred in October 2010 where the initial idea was expressed and voted on for approval. The IHE then worked to produce the volume 1 information from November 2010 through February 2011. During this time we established stakeholders, discussed architectural constraints of IHE member organizations as well as their current processes. For this trial implementation budgets were not considered. During the technical face to face meeting in February, volume 1 material was finalized and edited and work on volume 2 began. Volume 2 discusses the technical aspects of achieving interoperability of transport records. From February 2011 through May 2011 volume 2 focused on data goals of the transport record, the layers required to implement and the areas that needed to creation in order to accomplish the task. Once finalized during the May 2011 meeting, the entire profile was published for public comment by education institutions, software vendors and healthcare organizations. In July of 2011 the IHE reconvened to review the comments and adjust the profile accordingly. The result is the current version of the TRS Profile slated for trial implementation.

8 CONCLUSION

We've proposed how certain steps and artifacts are considered when choosing an EA method. We show that interoperability needs to be considered from the beginning using a phased approach seen in each of the four referenced EA technologies. We show sample artifacts that are a part of the interoperability framework and how they support the work products of existing EA. These will enable health care organizations to share information among multiple stakeholders. The goal is to provide

full functionality from the beginning as opposed to provide bridges in the end.

9 FUTURE WORK

We plan to implement a framework that will support the existing EA methodologies and include the additional artifacts that we discussed to prove interoperability between the various EA frameworks. This will show where the gaps exist between these major EA frameworks and what elements need to be extracted into a Universal Interoperability framework that will support all EA approaches.

The outcome is a process that can be introduced to provide functional interoperability among multiple systems where it was never part of the original implementation or to support systems that provided the underlying technology, but did not support total functionality.

The TRS profile is currently awaiting vendor implementation and testing at the 2012 North American Connectathon. The Connectathon tests HIT systems to foster compliance with standards, electronic health record system connectivity and interoperable exchange of patient health information. This is the ultimate proof of our working concept.

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