Implementing Interoperability using an IHE Profile for Interfacility Patient Transport

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Abstract - In August of 2006 the US Government passed an executive order to implement electronic health records by 2014. Recent moves in global healthcare IT standards address many medical domains; however, there has been little attempt to provide interoperability in transport medicine. We present an Integrating the Healthcare Enterprise (IHE) profile for Transport Medicine, to facilitate interoperability between various healthcare facilities and the transport environment utilizing distributed computing technologies such as SOAP envelopes for ebXML over mobile networks.

Keywords - Electronic health records, transport medicine, ebXML, SOAP, health information exchange

I. Introduction

On August 28th 2006 the US Government passed an executive order mandating standardization of Electronic Health Records and their interoperability among institutions. Proactively, in the previous year, through a contract with the US Department of Health and Human Services, the Health Information Technology Standards Panel [1] (HITSP) was formed. Since their inception they have defined standards for most aspects of healthcare. This process involved collaboration from many organizations to develop use cases to write standards for healthcare information technology (HIT). A major player is Integrating the Healthcare Enterprise [2] (IHE), when it came to interoperability. The IHE has been proactive in improving the way computer systems in healthcare share information. Since the IHE had already been developing interoperability standards, many of the HITSP documents utilized current IHE profiles. The IHE develops profiles that provide a common language between purchasers and vendors for discussing integration needs and capabilities of HIT products. It also provides clear implementation paths for communication standards supported by industry partners, which have been carefully documented, reviewed and tested [2]. To date there is a lack of HIT support for transport medicine and the information that need to be shared during the interactions between transport facilities. Such interactions may occur over state and federal networks known as Health Information Exchanges (HIE) and the National Health Information Network (NHIN) [3]. Figure 1 illustrates the technology gap in transport medicine.

While electronic documentation is being required in all other aspects of healthcare, the treatment and other procedures applied to patients during the transport are currently not electronically documented and therefore never becomes a part of the electronic health record. The period of time could last upwards of 8-12 hours during fixed wing transports. On September 17th 2010 our proposal to implement a new profile for transport medicine, specifically for interfacility transport (IFT) was accepted by the IHE. For the support of IFT profile, we developed enterprise architecture (EA) by taking hybrid approach [4]. In our approach, The Open Group Architecture Framework [5] (TOGAF) was considered for that need. As for the communication among the entities in the transport, distributed computing technologies are considered. Leveraging the advantages of ebXML using registries and repositories, messages are shared within a SOAP envelope in order to query, receive, update and send medical records in the transport environment using mobile networks.

Our goal is continued support of patient care utilizing technology to reduce errors, stop repeating tests, limit additional radiation, avoid adverse drug events [6], and eliminate extra costs. The proposed IFT profile provides the backbone to accomplish this in the transport environment. Any software applications that are built based on the profile provide increased workflow, decreased costs and improved patient care and outcomes. With secondary results of decreasing morbidity and mortality rates associated with delays in information and unnecessary procedures. It has been shown with other hospital systems that electronic billing and allocation of resources will continue to increase revenue in narrow cost margins [7].

II. Integrating the Healthcare Enterprise (IHE) Profile

IHE profiles coordinate the implementation of communication standards found in HIT. These standards include Digital Imaging and Communications in Medicine (DICOM), Health Level 7 (HL7) [8] and security standards.

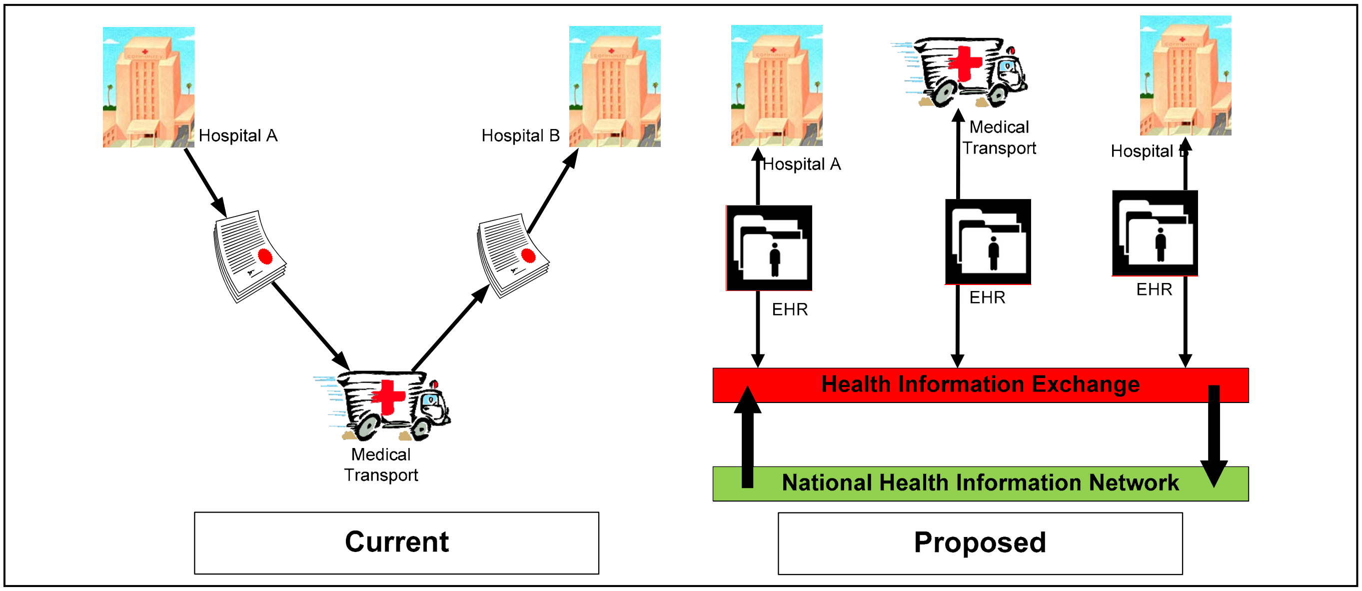

Figure 2. (a) Current Technology Gap (b) Proposed Solution

The profiles provide exact definitions of how standards can be implemented to support clinical needs. These combined profiles define the IHE technical framework as seen in Figure 2. This framework refers to functional components of a distributed healthcare environment as IHE actors [9]. The profile consists of two volumes. The first is an overview of the content. It includes use cases, process flow diagrams, implementation options and a basic dataset. Volume two contains specific XML schema for HL7 clinical document architecture, specific data specifications and their associated coding and transaction groupings with other profiles.

The IHE is not a standards committee but an implementation framework. The IHE looks at the current standards and chooses the one best solves the problem of interoperability. Often time the IHE will go back to a standards organization and ask them to create a standard that does not currently exist to solve the problem. The actors and transactions described are only abstractions from real world HIT. The framework attempts to avoid specific association with product categories and leaves such implementation to vendors. There are specific domains on which the IHE concentrates. Patient Care Coordination (PCC) is geared at the exchange of information to provide optimal patient care among care providers [10]. Currently this document successfully covers a majority of patient care areas; however, an important function that has been neglected, until now, is transport medicine and the Inter-Facility Transport (IFT) profile.

III. Transport Medicine

Transport medicine is a sub-specialty of both Emergency Medicine and Critical Care Medicine that has blended together to provide the best possible care with limited resources. This proposal narrows that gap of limited resources in an attempt to bring all available patient information to clinicians interacting with patients. The value of pertinent medical history is paramount when giving a differential diagnosis of a patient's current signs and symptoms. Currently this valuable resource is unavailable during transport medicine due to lack of any technical framework providing interoperability among healthcare systems of various institutions.

IV. IFT Profile

The IFT profile provides a portion of the PCC technical framework that addresses this deficit in HIT. We identified standards from HL7, W3C and ISO and developed use cases as the basis for the IFT profile. With this solid foundation, actors are defined, necessary functions are identified and transactions are specified to manage interoperability among the sending and receiving institutions and the transport environment.

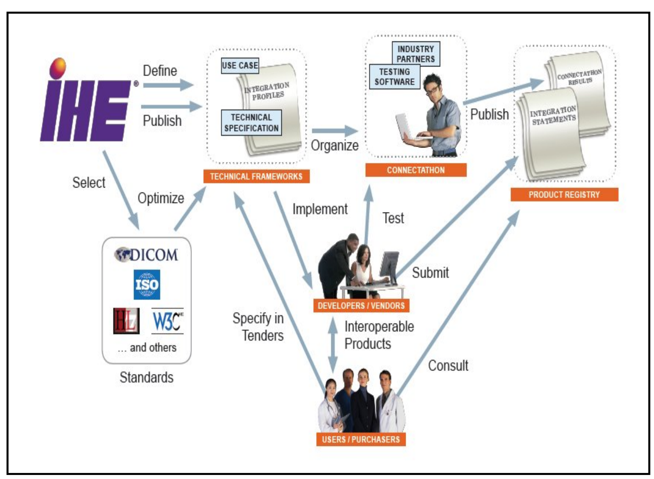

Figure 1.IHE Process

The profile looks at two specific use cases. The first deals with the pre-hospital environment and the second with an interfacility transport.

1) Use Case 1

A 47 year old white male patient visits his Primary Care Physician (PCP) because of a recent complaint of chest pain. During his visit the PCP obtains an EKG which shows significant changes in multiple leads. His PCP immediately calls 911. The PCP has an EMR system which is part of the local affinity domain and documents this case appropriately. The 911 providers also participate and are able to obtain the patient's current and past medical history and use this information in their own EMR system and update the record during the transport. Upon arrival at the local ED the 911 providers provide this updated information to the ED.

2) Use Case 2

A 6 year old Asian female patient has routinely been seen by specialty providers at a major medical institution with a focus on pediatric intensive care and disease process. The patient's parents notice an acute onset of symptoms associated with her condition that prompts them to bring their daughter to the local ED. While en route the parents notify the major hospital of the situation. The major hospital starts to arrange for rotor wing transport of the patient since they live in a remote area. The local ED is not part of the major hospital affinity domain and has a limited EMR. The ability to provide any records is limited to providing a CD with the information. The rotor wing transport staff consisting of a pediatric intensivist also does not participate in the major hospital's affinity domain, however using XCA, they are able to obtain limited information. They continue to update the EMR locally during the transport for near real-time viewing by the receiving facility and upon arrival can share this information in its entirety with the major hospital's EMR system.

The profile also consists of actors and their transactions. The specific actors for the IFT profile consist of a content creator and content consumer. The transaction is share content. Each actor can implement a view, document import, section import or discreet data import option. These allow specific parts of the EMR to be modified.

The IFT profile has specific groupings with other profiles in the IHE technical framework. When grouped with these actors, additional requirements are placed upon the current actors.

Content modules are defined to provide functional access to the document sets through ebRIM and ebRS. The specific EMR document needed to implement the above options are retrieved via the registry stored query transaction. This refers to the XDS (cross-enterprise document sharing) DocumentEntry.repositoryUniqueId. This can also be an XCA (cross-community access) document entry. The difference is geographical and defines whether or not the healthcare facility participates in the local HIE domain or whether the document needs to be retrieved from a foreign registry.

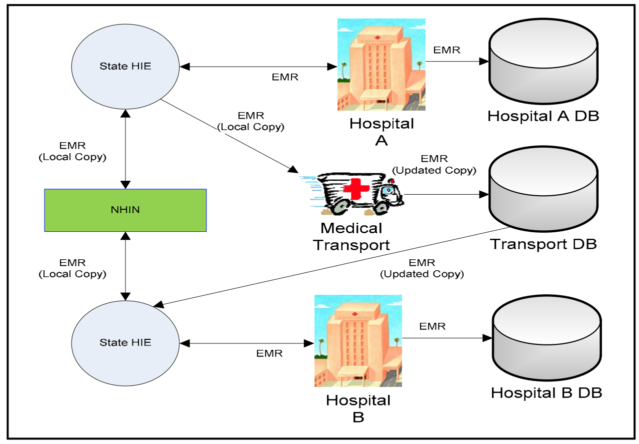

Figure 3. EHR Transmission over HTTP requests using SOAP envelopes with ebXML messages

We've indentified the necessary functions that each stakeholder provides for transport medicine. While the focus is clinical management of the acutely ill patient, there are support personnel that play an important role in the process. Billing processors are one example, without them the operation stops as funds would not be available to continue operating each plane, ambulance or helicopter that transports patients. After identifying each specific function, we focused on the transactions that occur between these functional groups to ensure consistency and reliability of information.

The IFT profile provides continuity of the electronic health record across transport medicine and avoids transitional artifacts which may provide essential patient information, but are often not reported or thought of as part of the normal workflow [11].

V. Proof of Concept

The IFT profile provides the backbone for transport medicine electronic medical records development. This utilizes hardware technology that supports a mobile environment, providing real time access to information. The ability to retrieve an accurate and current patient record might occur during travel to the sending facility or even at the patient's bedside. The gathered information would then be updated by the transport clinicians and on arrival at the receiving facility would be made available for their system. The IFT profile interacts with state and federal HIEs and the NHIN to retrieve the EMR, update and store a local copy as shown in Figure 3. These networks are being established to support the electronic transmission of health records. Our proof of concept system utilizes a MSSQL database and the Window Communication Foundation interface as the middleware for application communication.

When a patient needs to be transferred to another facility, the sending facility will contact the receiving hospital to provide verbal confirmation of bed availability and receiving physician service. The IFT profile uses the HL7 Admission, Discharge and Transfer (ADT) message service

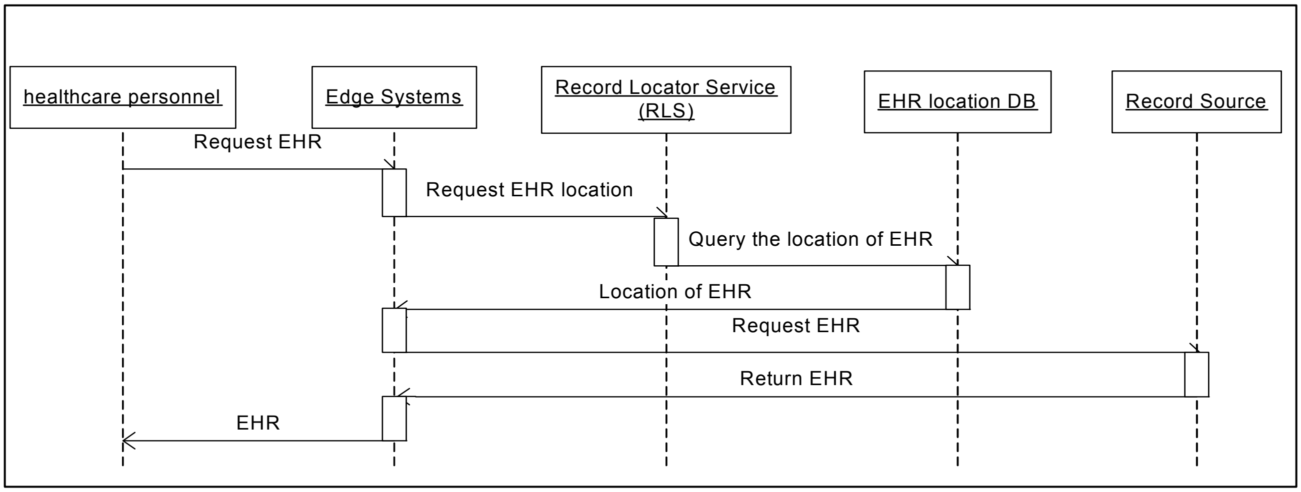

Figure 5. Record Locator Service

provide communication using ebXML. These discharge and transfer triggers, respectively A02 and A03, will kick start the process. These messages are written using XML format in version 3 of HL7 and will comply with the XML format of the standard electronic medical record. This standardization of an XML document allows proprietary vendors the ability to customize the GUI for respective clients. A02 and A03 messages are sent packaged in a SOAP envelope using HTTP GET or POST methods. When the transport unit received these messages to their systems, the GUI displays patient information and the ability to GET their chart.

VI. The Approach

Our approach supports the federal mandate of electronic medical records. While the majority of the HIT world focuses on major healthcare functions, there has been little effect on transport medicine. Our proactive approach to tackling this oversight solves confusion in a niche environment. With so many variables in the transport world each step needs to be precise, accurate and detailed. There are many possibilities and we provide the appropriate road map to accomplish these goals. After validation by the IHE, our profile becomes the basis for application development in the medical transport industry. The National Emergency Medical Services Information System consortium has begun to tackle the standardization of a data dictionary [12], but our framework provides the interoperability of such a data dictionary using ebXML [13] Registry Standards, SOAP [14].. ebXML was originally created for e-commerce to support large repositories of information cataloged in a registry service. This same fundamental solution can exist in healthcare and is the backbone of the entire system as seen in Figure 4. ebXML was created so that multiple partners would be enabled by the global use of electronic business information in an interoperable and secure manner. Trading partners use unique trading profiles that would describe their abilities. During interaction a CPA document describes a relationship as seen in Figure 5.

The transport environment, subjected to many variables, needs to have the most convenient way of accessing records. Version 3.0 of the Organization for the Advancement of Structured Information Standards approval of ebXML Registry utilizing SOAP style architecture ensures that a default URI is assigned to all content and meta data. IFT profile exploits this feature to provide access to records using only a mobile internet connection with an HTTP GET or POST request as part of SOAP message as seen in Figure 6.

These transactions will be authenticated using a SAML token. This is predicated on the fact that the system providing the assertion is trusted and assumed correct.

The ability to interact with the sending and receiving institution utilizing HL7 ADT messages provides means of seamless interoperability between the transport unit and the medical facilities they service. Our implementation trials involve the critical care transport team at the Johns Hopkins Hospital in Baltimore, Maryland. This transport team, “Lifeline”, serves a broad range of patient populations during transports both inside the hospital between ICUs and

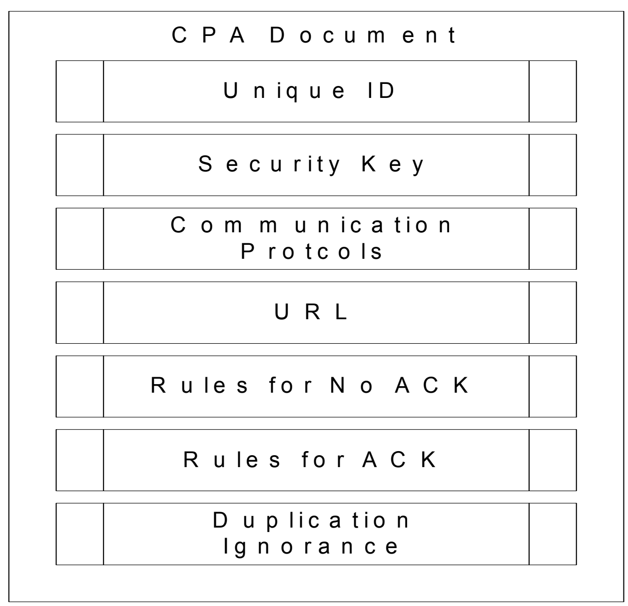

Figure 4. CPA Document Structure

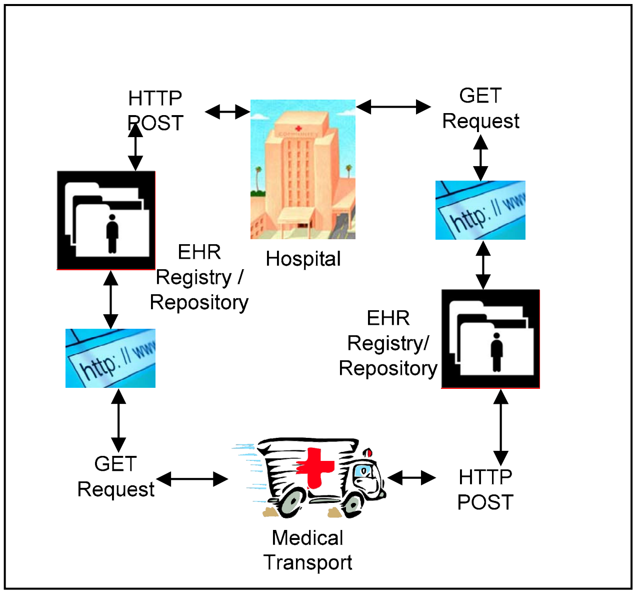

Figure 7. IFT Profile Interoperability

procedure areas as well as outside the hospital using ground and aero medical transport to include rotor wing and fixed wing. The team will use implemented software which supports the IFT profile. Feedback provided by both clinicians and supporting roles will validate our framework. Successful validation is defined as the ability to obtain and share all pertinent and past medical history, up to date treatment and care, vital sign observations and any interventions during transport with all aspects of the medical institution's EHR system. In addition our system will be tested and validated at the annual IHE Connectathon to ensure interoperability with other software systems. This event brings hundreds of HIT vendors together to prove their ability to successfully implement IHE profiles.

We are using a third party document repository that will store documents and make them available. These repositories may be managed by the State, Federal Government or individual healthcare facilities. In this situation we have an actor defined as the *document source* whose role is a system that submits documents and metadata. Another actor defined as the *document repository* whose role is a storage system and acts to forward the metadata to a document registry for future query and finally an actor defined as a *document recipient* who role is a system that receives documents and associated metadata. When systems communicate using ebXML messaging they do so under a set of rules agreed upon in the transaction profile as shown in Figure 7.

This uses an asynchronous message and response. The protocol will be encapsulated in SMTP. The next layer is SOAP with MIME attachments. This includes a text/xml SOAP Envelope consisting of two parts, the SOAP Header and Body. The next part is the submit object request which is the ebXML Registry Message. This will include all pertinent documents that are being sent to the document repository and eventually updated in the document registry for future query by a document recipient.

This email message contains a *from* email address which is that of the document source a *to* email address which is the document repository or document recipient. A datetime stamp, MIME indicator and SOAPAction: "ebXML".

This contains a header and body. Header contains information using ebXML data elements. These would include eb:From, eb:To, eb:CPAId, eb:Action (submit objects), eb:MessageID, eb:Description, optionally eb:AckRequested. In addition a way to link references to documents and their appropriate identifiers using a document identification system. This reference is to attached documents in an xml message referred to as metadata.xml. The MIME header might look similar to this:

--------------Boundary
Content-Type: text/xml; charset="UTF-8"; name="METADATA.XML"
Content-Location: METADATA.XML
Content-Disposition: attachment; filename="METADATA.XML";
Content-Description: Send Document Set Metadata
<?xml version="1.0" encoding="UTF-8"?>
<rs:SubmitObjectRequest xmlns:rs=…>
…
</rs:SubmitObjectRequest>
--------------Boundary

The goal is to provide a convenient mobile way of accessing documents in the transport environment utilizing existing architecture as well as updating those documents for real-time viewing by the receiving healthcare team, creating a virtual patient.

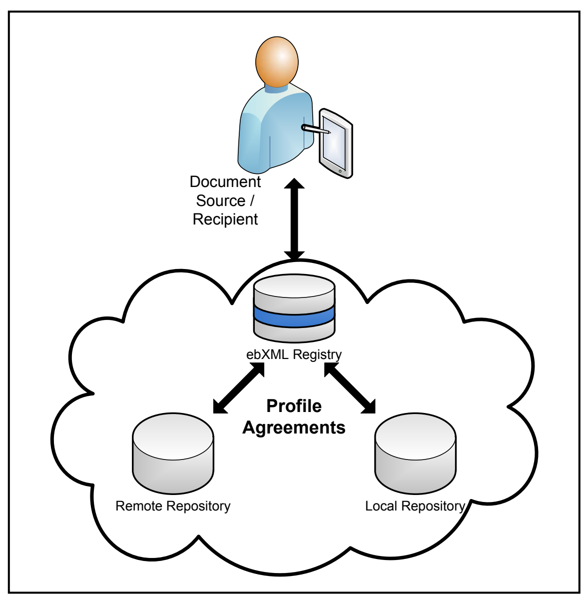

Figure 6. ebXML Architecture

VII. CONCLUSION

In this paper, we have proposed an IFT profile and related distributed computing technologies. Our profile creates interoperability through the exploitation of HL7 ADT messages, commonly used inside an enterprise system, to communicate with an outside resource utilizing a SOAP HTTP approach to uniquely identifying each resource as completed in the ebXML Registry Information Model version 3. ebXML messages in SOAP envelopes are sent and received providing interaction among two systems sharing a single electronic record. We utilize SAML assertions to provide authentication from trusted sources. EMRs are located and updated using our RLS services by finding appropriate registries and repositories. This updated information will be shared in near real time with receiving facilities so that the current condition of any patient is readily accessible for ongoing diagnosis and treatment by the healthcare team.

VIII. FUTURE WORK

We have begun to investigate the use of REST messages as a way to provide a more streamline messaging service for the mobile transport environment. Future profile implementations will include this protocol.

Using the IFT profile, developers will also be able to provide lower cost product solutions for their institutional customers based on their ability to interact with the interoperability roadmap proposed by the Health Information and Management Systems Society. The EHR roadmap details the steps that have been taken and need to be taken to achieve complete interoperability [15]. The IFT Profile will be expanded to support this venture and provide means for completion of all interoperability standards and the complete electronic health record.

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