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ELECTRONIC HEALTH RECORD INTEROPERABILITY ACROSS TRANSPORT MEDICINE

by

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DISSERTATION APPROVAL PAGE

This is to certify that the dissertation prepared by Philip DePalo, entitled "Electronic Health Record Interoperability across Transport Medicine" has been approved by the dissertation committee as satisfactorily completing the dissertation requirements for the degree of Doctor of Science in Information Technology.

Chair, Dissertation Committee, Dr. Yeong-Tae Song	11-15-13 Date
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I dedicate this dissertation to my mother,

for her faithful support and everlasting love.

I will always be your touchstone

ABSTRACT

There is an expectation that when a patient is transferred between two different medical institutions, their medical records will follow them. While this is becoming true for the majority of the patient population, there is a gap for those who must be medically transported by either ambulance, helicopter or fixed wing. Developing this type of IT architecture, our research will focus on properly aligning the concept of electronic health record interoperability across the transport medicine environment in a seamless fashion as well as address the contribution, expectations and promises associated with a universal electronic health record as defined by the Health Information Technology Standards Panel (HITSP).

In August of 2006 the US Government passed an executive order to implement electronic health records by 2014. We developed 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.

Current Enterprise Architecture (EA) models provide little guidance, if any, for implementing interoperability in healthcare organizations. We developed an EA interoperability method that leverages current EA models and business IT. 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.

We developed an algorithm which searches for available documents that are relevant to the patients' current conditions based on medical coding within these documents, clinical document architecture (CDA) documents, using HL7 message exchange mechanism in SOAP envelopes. These CDA documents are then consolidated into a single transport record summary (TRS) document to filter out redundancies and provide destination medical service provider with the most pertinent information that is readily accessible to both human and machine. In a time critical environment, access to multiple documents from difference sources is not likely feasible. For this reason, we developed a CDA document consolidation tool, the TRS Constructor, which creates a TRS by querying and analyzing patient's multiple CDA documents. The new TRS will be registered into the Health Information Exchange (HIE) environment for cross-reference across healthcare facilities and other providers.

The need to support transport clinicians with the most valid pertinent information about each patient is the main focus to our research. We built a medical ontology around transport medicine protocols which associated multiple diseases and their associated symptoms. We developed semantic queries using the patient's current symptoms as input and the query result is analyzed by our algorithm to derive probable diseases. The algorithm uses types of associated symptoms based on the ontology to quantify a confidence level for each possible disease. If the disease ruled in, we presented this information to the clinician as part of a decision support system. We used this output to query the patient's existing EHR for relevant medical history regarding the current disease process. We provide both the probable diagnoses along with the patient's relevant history in a single XML resource document.

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ABBREVIATIONS

CAI	Context-Aware Inference
CDA	Clinical Document Architecture
DBMS	Database Management System
HIE	Health Information Exchange
HIT	Health Information Technology
HITSP	Health Information Technology Standards Panel
HL7	Health Level 7
IHE	Integrating the Healthcare Enterprise
LINQ	Language Integrated Query
OWL	Web Ontology Language
RDF	Resource Description Framework
SPARQL	SPARQL Protocol and RDF Query Language
TOGAF	The Open Group Architecture Framework
TRS	Transport Record Summary
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
W3C	World Wide Web Consortium
XML	Extensible Markup Language
XSD	XML Schema Definition

Chapter 1

Introduction

The modernization of health care has created a gap among institutions due to varying degrees of specialized care available at different institutions and unique practices followed at each institution. These differentials give rise to difficulties in maintaining continuous care for a single patient across these organizations as well as standardized care during transport among different institutions [1]. With new mandates and efforts underway to support universal health care, and records pertaining thereto, bridging the gaps in care between organizations is becoming a reality. However, the issues that disrupt continuous care when a patient is transported between institutions have yet to be effectively addresses. Transport via ambulance is a critical time for a patient given the relative lack of available resources in a ground ambulance, helicopter or fixed wing aircraft. The ability to access a patient's record and

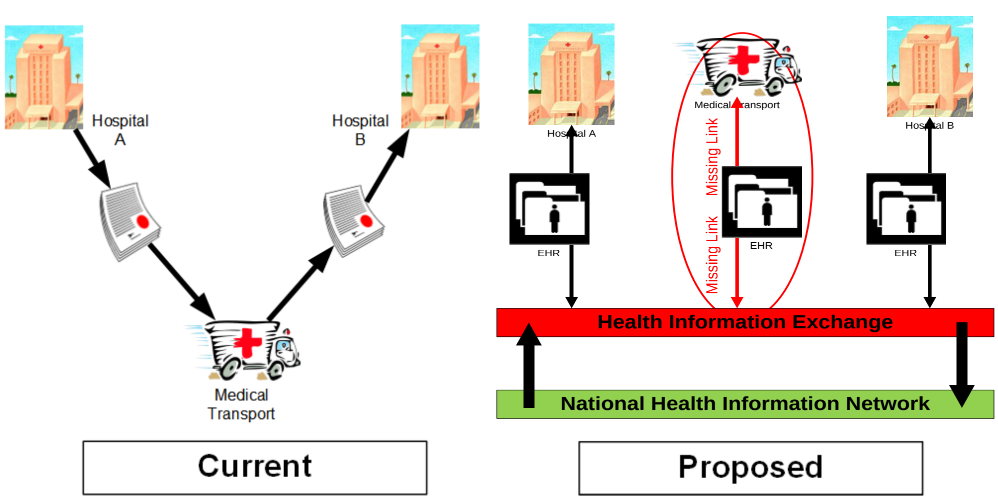

Figure 1. Transport Medicine and the HIE

diagnose and treat any acute issues that may arise during transport is essential to the wellbeing of patients. Very little currently is being done to ensure transported patients receive optimal care that meets the highest standards.

While support exists to create an electronic medical record for a specific patient during transport via ambulance, current technology does not provide means of accessing prior patient information or filling in repetitive sections such as patient medical history, medications and demographics. The ability to receive and transmit this information in real time from the point of patient contact until care is transferred to the receiving facility is paramount in ensuring patient health.

Currently an interoperability specification [2] that deals specifically with the transfer of care does exist. However, this scenario assumes a patient is able to schedule an office visit with their new clinician. This is not the case with transport medicine, which deals with sudden, unpredictable emergencies. Figure 1 shows the current technology and missing link in transport medicine.

1.1 Problem

Our research aims to develop IT architecture that provides interoperable health information technology (HIT). The research questions under investigation are:

1. Can we provide a method to access available electronic health records for transport clinicians?
2. Can we create an additional phase in the enterprise architecture process to create interoperability in transport medicine?

3. Can we provide a problem focused history based on accessible electronic health records?
4. Can we provide a diagnosis decision support system based on the patient's current symptoms and previous medical history?

This will define how the electronic health record is transmitted and used by the inter-facility transport medicine team through any particular health information exchange (HIE) [3]. Embodying the current standards proposed by the Health Information Technology Standards Panel (HITSP), a profile will be created for inter-facility transport. This will utilize Integrating the Healthcare Enterprise (IHE), which defines IT Architecture profiles for the healthcare world. IHE Profiles organize and leverage the integration capabilities that can be achieved by coordinated implementation of communication standards, such as DICOM [4], HL7 [5], W3C [6] and security standards. They provide precise definitions of how standards can be implemented to meet specific clinical needs [7]. Aligning with each institution's business objectives, shown in Figure 2, our research will be based on meeting the goals of transport medicine and the government's goal of providing every patient with an electronic health record.

Currently, medical institutions only have a solution for the pre-hospital setting; however, our research will include the inter-facility environment. HITSP IS04 refers only to pre-hospital 911 settings [8].

HITSP has begun to adopt Health Level 7 [9] as the standard for transmission of information between electronic health record (EHR)

Business Objectives

EHRs must be complete, accurate, timely and secure.

Standard will be applicable regardless of vendor software.

Technology will be adaptable to a variety of environments.

Figure 2. Sample Business Objectives

applications. HL7 makes reference to the ISO OSI architecture model application layer. HL7 focuses on the application layer protocols for the health care domain independent of the lower levels; lower layers are considered to be tools. When it comes to the transmission of the EHR, focus is directed to lower levels such as the data link layer and the physical layer. No specific communication protocol is standard to HL7.

XML has been the accepted standard format for the EHR; however, there has been little research into solving the problem of transmission between medical institutions or the transport environment. HITSP has just begun to delve into this type of research.

HITSP IS04 currently defines IHE profiles for both the emergency department referral (EDR) and the emergency department encounter summary

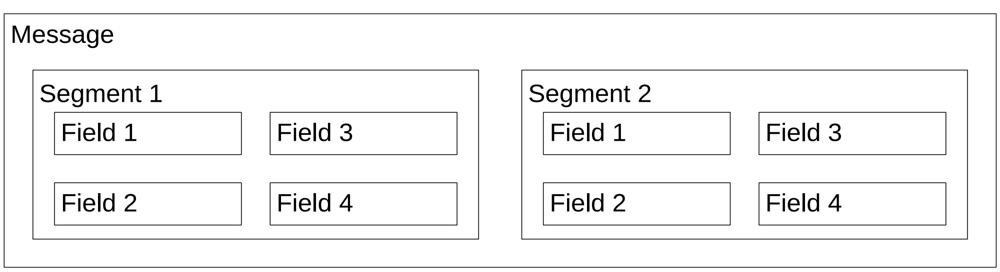

Figure 3. HL7 ADT Message Diagram

(EDES). Both of these profiles are geared toward the pre-hospital provider that is typically referred to as the 911 system. However, no profile has been defined for the mobile inter-facility providers that hold the same licensure, but handle a different type of care. Such care is usually provided with an expanded scope of practice as well as additional personnel such as a physician or nurse. This type of medicine is referred to as transport medicine. A profile to be utilized during transport needs to include definition of the sending and receiving of this information during the patient encounter.

HL7 is broken down into functional groups which might contain admission, discharge and transfer (ADT), physician order entry, finance, etc.

HL7 A02 & A03 Message Examples

```
MSH|^~\&|AccMgr|1|||20050110114442||ADT^A02|59910287|P|2.3|||
EVN|A02|20050110114442|||||
PID|1||10006579^^^1^MRN^1||DUCK^DONALD^D||19241010|M||1|111^DU
CK
ST^^FOWL^CA^999990000^^M|1|8885551212|8885551212|1|2||40007716^^
^AccMgr^VN^1|1231212
4||||||||||NO
PV1|1|I|IN1^214^1^1^^^S|3||PREOP^101^|37^DISNEY^WALT^^^^^^AccMg
r^^^^CI|||01||||1|||37^DISNEY^WALT^^^^^^AccMgr^^^^CI|2|40007716^^^Ac
cMgr^VN|4|||||||||||||||||1||I|||20050110045253||||||
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```
MSH|^~\&|AccMgr|1|||20050112154645||ADT^A03|59912415|P|2.3|||
EVN|A03|20050112154642|||||
PID|1||10006579^^^1^MRN^1||DUCK^DONALD^D||19241010|M||1|111^DU
CK
ST^^FOWL^CA^999990000^^M|1|8885551212|8885551212|1|2||40007716^^
^AccMgr^VN^1|123121234||||||||||NO
PV1|1|I|IN1^214^1^1^^^S|3||IN1^214^1|37^DISNEY^WALT^^^^^^AccMgr^
^^^CI|||01||||1|||37^DISNEY^WALT^^^^^^AccMgr^^^^CI|2|40007716^^^Acc
Mgr^VN|4||||||||||||||1|||1||P|||20050110045253|20050112152000|3115.89|3115.89
|||
```

Figure 4. HL7 Message Examples

These functional groups are further broken down into message types which are implemented in various combinations to support customization of high level business rules. For example, when a patient is to be transferred via ambulance, this event would feature a combination of a discharge and transfer triggers, respective codes A02 & A03. That is, the patient needs to be discharged from the current hospital and the covering physician as well as admitted to the receiving hospital and transferred to the accepting physician.

Each message type has its own definition that includes the segments below that make up the message type. Segments provide a local grouping for data elements, such as the patient identification (PID) segment. This would include the name, social security number, medical record number, date of birth and additional demographics. Each of these is referred to in fields shown in Figure 3 . Figure 4 shows two example messages using HL7 markup.

The communication method typically uses a client/server point-to-point protocol. A third party program would have to be authenticated on the proprietary network of the sending and receiving hospital in order to transmit the electronic health record.

There exists a phased implementation for the interoperability of information [10]. We intend to embody this type of implementation which has already proved successful in the first three phases. Phase 1 shares simple text-based medical summaries. Phase 2 involves patient-provided information, lab work, emergency department summaries and prescription information along with other coded information. Phase 3 begins to include all aspects of a patient's detailed record and provide for quality control and public health support. Phase 4 deals with collaborative care, real-time quality reporting and health surveillance.

Our research will utilize the Edge-System communication services [11] along with the Health Information Exchange (HIE) and National Health Information Network (NHIN) core communication services. An edge-system is any end-user organization that will access medical records. The five functional components are Patient Identification Management, Security and Access Control, Persistent Information Management, Dynamic Information Access and Workflow/Quality as shown in Figure 5. Patient Identification and Access Control are foundations of the system.

Access control is assigned by each Edge System administrator and dictates which components are able to access the HIE and NHIN through the internet. Access to these services depends on three functional components.

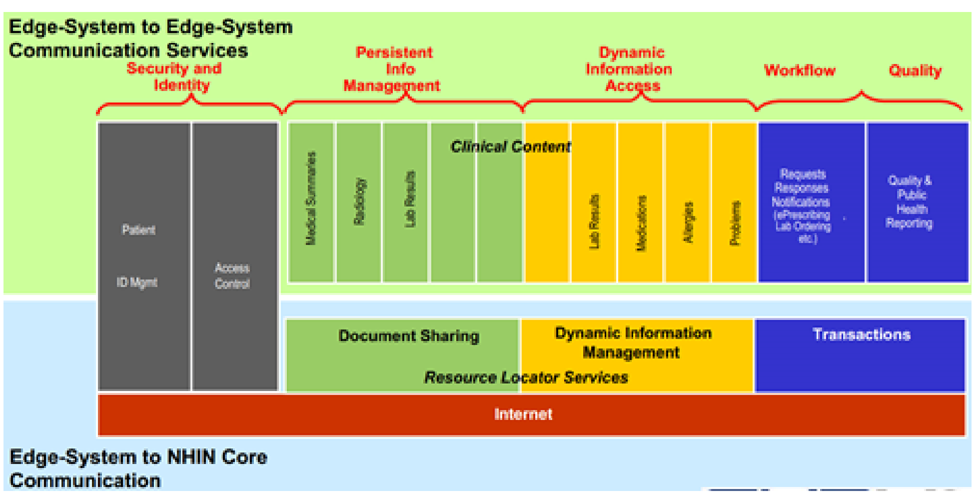

Figure 5. Roadmap Infrastructure Requirements [11]

First, each edge system is responsible for their availability. Second, each HIE, typically state controlled, must be available and finally the NHIN, controlled at the federal level must be available. Failure at the edge system level will make those EHRs residing at each edge system unavailable to the rest of the network. If the HIE is unavailable, multiple edge systems, will not be able to communicate with each other or access the NHIN. Failure of the NHIN will not allow communication between HIEs.

Persistent Information Management is comprised of the static documents that can be shared amongst clinicians in the health care environment. This is not real time information, but rather information that is continually added to the health record longitudinally. This information as shown in Figure 5 could reside in either the Edge-System or on the NHIN core.

Dynamic information access refers to data elements that routinely change during the patient's encounter. For example common lab results constantly change values and as such, must be dynamically updated.

Workflow refers to the actual functions of the associated data elements. For instance when a medication is ordered through e prescribing, this process requires medication interaction checking as well as medication allergy contraindications.

Quality and public health reporting is an obligation of the healthcare facility to update state and federal sources with possible epidemics or community acquired diseases that can have an impact on the local

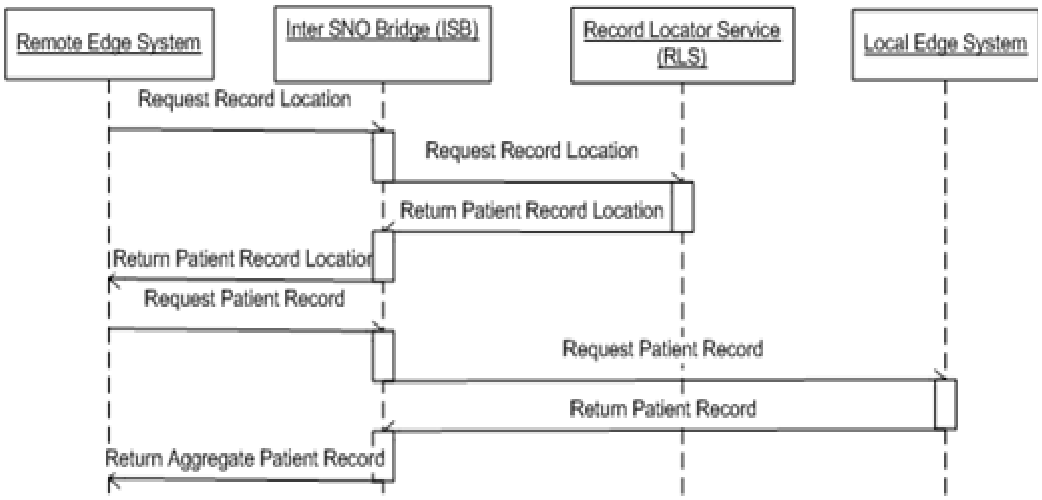

Figure 6. Inter SNO Bridge Interaction

environment.

The health information exchange uses a record locator service (RLS) which is a master patient index that is part of a sub-network organization (SNO). These refer to records found at multiple institutions in the same SNO. The identification might be a medical record number, but could also possibly be a combination of data elements in the event of a previously unidentified patient [12].

When a patient originates from another SNO [3] or an entirely different state and HIE, the Inter-SNO Bridge (ISB) [3] supports the connections among various SNOs, as shown in Figure 6.

Following the roadmap in Figure 5 is beneficial in multiple ways. First it is based on implemented solutions with standardized interoperability technology. It continues to gather validity through global adoption and thus allows for application in global markets and a diverse patient population. The roadmap is the result of a collaborative process involving stakeholders from all relevant backgrounds, including health care, billing, standards organizations, government, private industry, HIT advocacy groups and others. Finally, this is the direction the government mandated initiative is heading and as such provides the basis for a variety of vendor market shares and interoperabilities. Our research will continue to follow this roadmap as we invent a new way to provide this information for patients of transport medicine.

HITSP & The National Emergency Medical Services Information System (NEMSIS) has acknowledged the gap in this area; our research aims to narrow that gap by achieving complete electronic healthcare documentation for each US citizen. NEMSIS is a project which aims to implement an electronic Emergency Medical Services (EMS) documentation system in every local EMS system as well as a state EMS system which will utilize local information by means of the XML standard [6].

1.2 Scope

We aim to define an IHE profile and IT architecture to describe the continuity of EHRs between transport medicine and the sending and receiving facilities by using an HIE, termed inter-facility transport (IFT). This HIE will use the associated XML schema formed from NEMSIS compliant language [13]. Such IT architecture is needed to support all aspects of transport medicine. This is because IT architecture is an organized set of consensus decisions on policies and procedures, common solutions, services, standards and guidelines that organizations use to build their IT infrastructure. Such definitions are often made as a result of intense interactions with system users and the customers. A more in depth analysis will need to be made to determine what the exact nature of our research will be as it relates to the business processes of those involved in both the transport environment and hospitals [14]. Those users will provide the specific needs of the system to help define this profile. The profile must utilize the ISB and span multiple HIEs. This poses a challenge that will not be typical of the EHR system. Figure 7 illustrates how a transport will work. Typically an EHR will not move outside of the SNO, but in transport medicine this will be a daily occurrence. Medical transport would query the HIE using the RLS and locate Hospital A's copy of the current EMR from their database. The medical transport would then continue to update the EMR as patient care proceeds. The medical transport

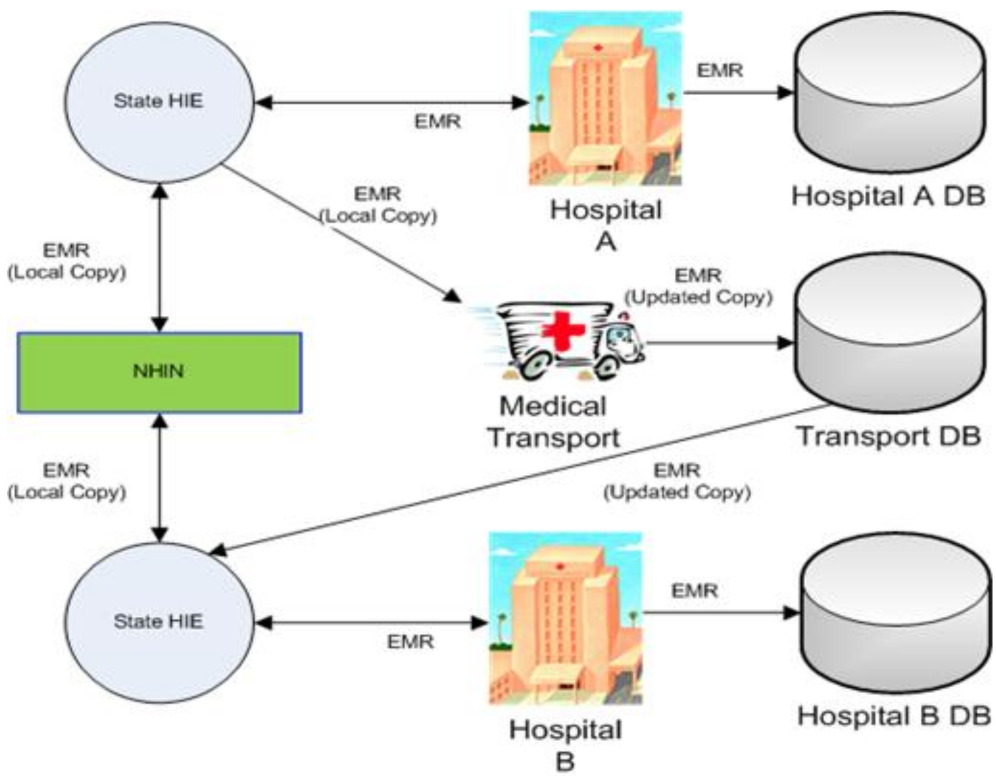

Figure 7. Electronic Medical Record Update Diagram

would then push its updated EMR to the transport DB. Hospital B then queries the local HIE using the RLS to locate the most recent copy of the EMR found in the transport DB. Hospital B would then use this copy as it continues patient care. In the meantime, Hospital B is able to locate Hospital A's copy of the EMR prior to or during transport. However, this would not be the most up to date copy when medical transport begins care.

Figure 8 shows how the incremental update of an EMR would work. It has been proposed that access to the EHR be controlled by the patient [15]; however, in many transport situations, especially those in which a higher level of care is needed, the patient may not be able to authorize additional healthcare providers due to their altered level of consciousness.

In an attempt to reduce the number of transitional artifacts [16] (the pieces of intermediate documentation that bridge the gap between physical

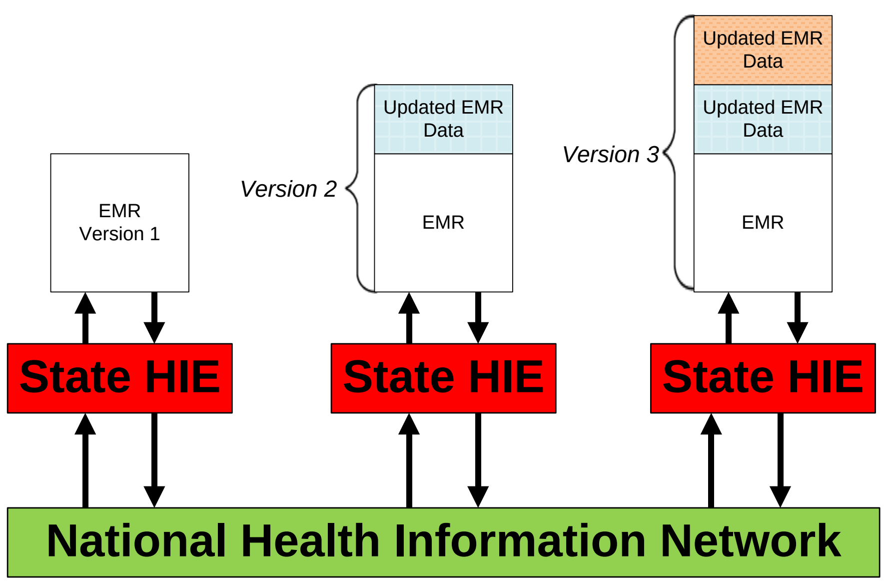

Figure 8. Incremental EMR Capture

patient care and the EHR), we need to look at specific sets of data that will be documented or are typically recorded in real time during an acute situation. Capturing information using a slate pc with a touch screen that would accept hand written input and convert information to relevant parts of the EHR is essential in these transport environments. During disasters in Haiti, for example, a makeshift network of electronic and paper based medical record systems was established in an attempt to accurately document as much patient care as possible. It has been shown that a hybrid system of paper-based and electronic documentation works in unstable environments [17]. Transport medicine personnel must deal with such environments. However, taking this a step further than the Haitian study, we aim to bridge the paper-electronic gap by providing a method that allows the ease and portability of a paper-based system through using electronic media.

A standardized dataset to define each item that exists within the record will also be researched and defined. Finally, our goal is to make this system interoperable with all other aspects of the existing EHR backbone using SOAP [18] messages with the associated XML [6] language. Validation of our efforts will be performed by those who are responsible for creating these profiles in the IHE and HITSP committees. Our research aims to serve the transport environment and how the EHR interacts with transport units and the medical facilities they serve.

Chapter 2
Literature Review

2.1 Transport Record Summary Profile Work

On August 28th 2006 the US Government enacted an executive order mandating standardization of Electronic Health Records and their interoperability among institutions. The previous year, through a contract with the US Department of Health and Human Services, the Health Information Technology Standards Panel [2] (HITSP) was proactively formed. Since its inception the HITSP has defined standards for most aspects of healthcare. This process involved collaboration of many organizations in the development of use cases and writing standards for Healthcare Information Technology (HIT). HIT quickly became a major player is Integrating the Healthcare Enterprise [7] (IHE), when it came to developing and implementing interoperability. The IHE has been proactive in improving how healthcare computer systems share information. Since the IHE had already been developing interoperability standards, many 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, all of which have been carefully documented, reviewed and tested [7]. To date there is a lack of HIT support for transport medicine and the information that needs to be shared during interactions between transport facilities. Such interactions may occur over state and federal networks known as Health Information Exchanges (HIE) and/or the National

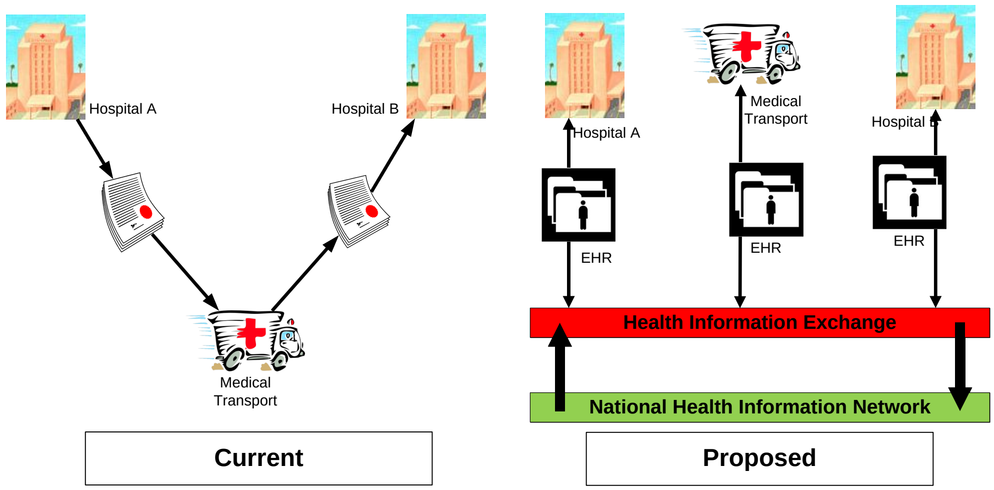

Figure 9. (a) Current Technology Gap (b) Proposed Solution

Health Information Network (NHIN) [19]. Figure 9(a) illustrates the technology gap in transport medicine through the current method of copied paper charts. Figure 9(b) illustrates how we propose records to be shared between medical facilities and medical transport.

While electronic documentation is being required in all other aspects of healthcare, the treatment and other procedures applied to patients during transport are currently not electronically documented and therefore never become a part of the electronic health record. The period of time could last upwards of 8-12 hours during fixed wing aircraft 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. To support the IFT profile, we developed Enterprise Architecture (EA) by means of a hybrid approach [20]. In our approach, The Open Group Architecture Framework [21] (TOGAF) was considered to fill that need. As for communication among entities involved in patient transport, distributed computing technologies have been 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 improved communication technology to reduce errors, stop repeating tests, limit additional radiation, avoid adverse drug events [22], and eliminate extra costs. The proposed IFT profile provides the backbone of communications technology and software by which to accomplish this goal in the transport environment. Software applications that are built based on our profile provide increased workflow, decreased costs and improved patient care and outcomes. Fundamentally significant results include decreasing morbidity and mortality rates associated with delays in information and inflicting 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 [23].

2.2 Enterprise Architecture in Healthcare Interoperability

Enterprise Architecture (EA) is the act of organizing logical flow between applications, data and infrastructure technologies captured in policies and technical choices which represent the organization's business principles and practices throughout all projects [24]. Architecture can be viewed as a blueprint for the optimal and target-conformant placement of resources in the IT environment to support business functions [25]. EA is a comprehensive description of all of the key elements and relationships that make up an organization [26]. EA is used to define alignment of an organization's mission, goals, and objectives within the information system [27]. 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. Steps taken when implementing EA methodology will result in the ability to improve understanding of healthcare functions and show better alignment with IT and business architecture [28]. The acceptance of an EA approach in healthcare has been slow due to the complex nature of the environment and the severe consequences of any one single error which could relate to a poor patient outcome. Interoperability binds together real-time, life-critical data that will transform the way we provide healthcare [29]. 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 of which can result in high patient morbidity [24].

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 hospitals 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 including laboratory, physical therapy and environmental services [30]. Sharing these services outside the organization adds 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 to ensure best outcomes for patients [31].

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. The Veterans Health Information System and Technology Architecture (VistA) [32] is an example of such technology architecture that has been deployed by UC Davis and Texas Tech. It is interoperable and was built with interoperability in mind. VistA 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 will look 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.

2.3 Clinical Document Architecture Consolidation

Sharing a single medical record among several medical facilities is the goal of the US Government defined "meaningful use directive." It not only includes the adoption of the electronic health record (EHR), but also the ability to use it in multiple specific ways. Blumenthal [33] objectifies the need to exchange key clinical information electronically between providers. Our proposed method addressed this objective in a patient population that is transported annually by critical care transport teams. Johns Hopkins [34] estimates 27,500 patients are transported by the Johns Hopkins Lifeline Critical Care Transport team annually. This accounts for only one hospital in one state. Currently transport medicine clinicians do not have access to patients' electronic health records. Boockvar [22] hypothesized transitions of care without an EHR would lead to increased adverse drug events. EHR absences can also lead to unrecognized medical drug allergies, incomplete medical histories and poor access to previous care provided. Our methods provide access to a health information exchange (HIE) to enable retrieval of current medical documents on a patient requiring transport. These methods will reduce errors and improve patient outcomes through more accurate directed care and medical histories.

We propose new methods of querying medical documents during patient transport and consolidation of them into a single XML compilation based on relevant information for the specific problem the patient is experiencing at that time. This query uses the local HIE and the eHealth

Exchange, formerly the Nationwide Health Information Network [35]. Through these two step processes, we form a machine readable XML-based CDA document that provides up-to-date information of the patient.

2.4 Improving Patient Care in Transport Medicine through an Ontological Approach

The ability to share medical data with a variety of institutions has come to the forefront of healthcare in the US and other countries. Currently documents are being created for a variety of patient encounters and reports. These documents are stored in large central databases so that others may access them for their own use as shown through the steps of Figure 10. When a clinician accesses this registry of information they are able to search for all documents available for any given patient. This is enabled by Health Level 7(HL7) Clinical Document Architecture (CDA) [5] standard which is an XML based version of the medical record produced by HL7 and ANSI-accredited standards developing organization for healthcare. Multiple types of CDA documents exist, where there is often a lot of information, some duplicated, among all these documents. In transport medicine, clinical providers need quick access to relevant information about the patient they are treating due to the time contingent environment in which they work. In such an environment, providers may not have the time or resources to sift through a large number of electronic CDA documents in order to diagnose the patient or determine their relevant past medical history as it relates to the current problem.

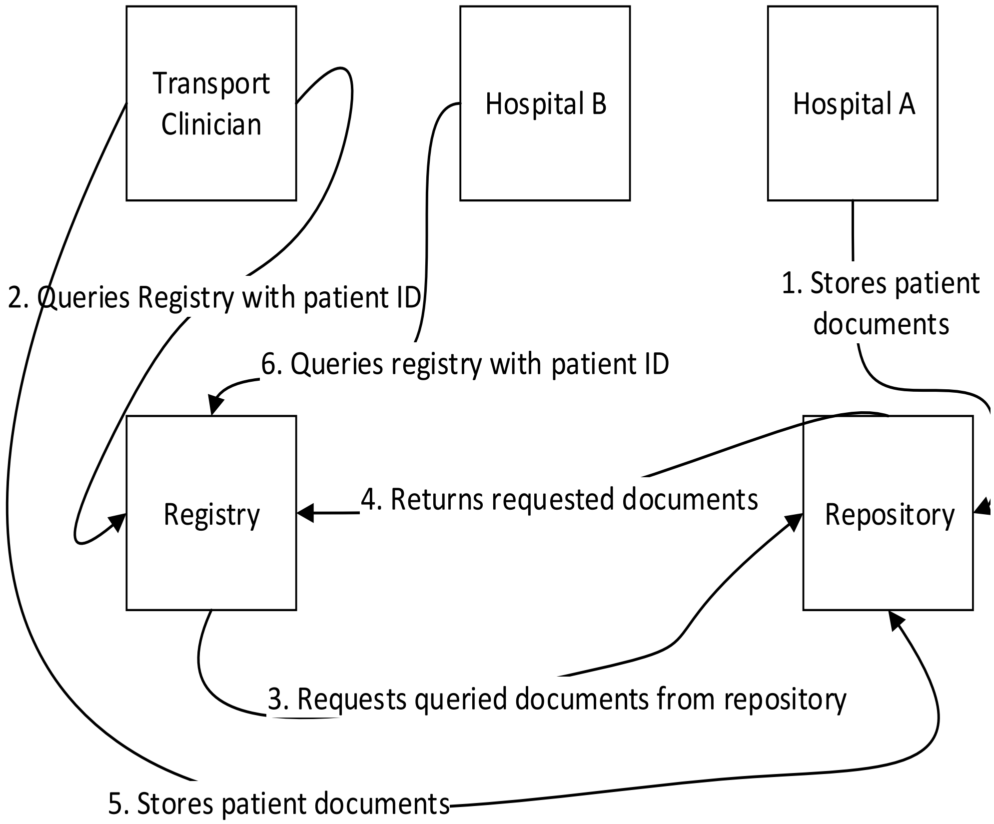

Figure 10. Transport Messages

CDA documents might contain a variety of similar terms relating to the same diagnosis repetitively, which may further delay critical treatment of the patient population [36]. To date there has been no proposal for a standardized search through this type of data, especially a search that is meaningful and effective for the clinician [19]. Even though current search technology utilizes relational databases, their ability to represent relationships dynamically among each different element located in different locations is limited. To overcome such limitations, an ontological approach is investigated and considered. An ontological search is an attempt to go beyond simple keyword search.

Ontologies support URI objects that can be uniquely identified across areas of all internet domains [37]. Agarwal [38] states that an ontology is, therefore, the manifestation of a shared understanding of a domain that is agreed between a number of agents. Thus such agreement facilitates accurate and effective communications of meaning, which in turn leads to other benefits such as inter-operability, reuse and sharing. The ability to share data is a meaningful use objective [33]. Ontologies have a lot more flexibility in handling their data than relational databases, but deductions cannot be made with such functionality [39]. Our focus is on the electronic health record (EHR) and its ability to consume, reuse and share available data within the EHR in order to achieve interoperability in transport medicine. This may prevent repeated tests, medication errors and potential redundancy.

Chapter 3
Transport Record Summary Profiles

3.1 Integrating the Healthcare Enterprise (IHE) Profile

IHE profiles coordinate implementation of communication standards found in HIT. These standards include Digital Imaging and Communications in Medicine (DICOM), Health Level 7 [9] (HL7) and security standards. 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 11. This framework refers to functional components of a distributed healthcare environment for IHE actors [40]. The profile consists of two volumes. The first is an overview of the content. It includes case studies, process flow diagrams, implementation options and a basic dataset. Volume two contains specific XML schema for HL7 clinical

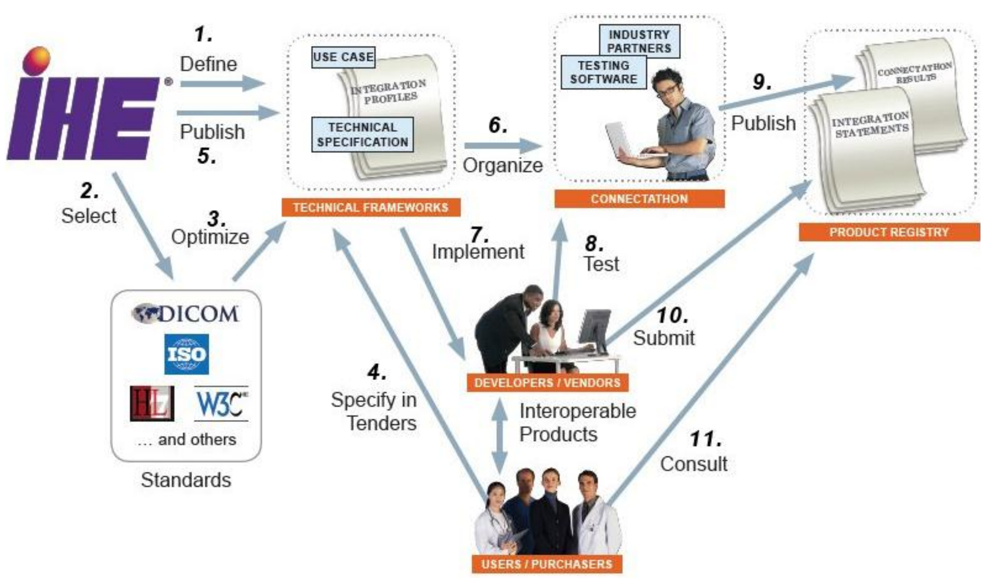

Figure 11. IHE Framework Process

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. Oftentimes the IHE will go back to a standards organization and ask them to create a standard that does not currently exist to solve a particular problem. The actors and transactions described are abstractions from real world HIT. The framework attempts to avoid specific associations with product categories and leaves such implementation to vendors. There are specific domains on which the IHE concentrates. Patient Care Coordination (PCC) is geared to the exchange of information to provide optimal patient care among care providers [41]. 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.

3.2 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 the limited resources available aboard a ground vehicle, helicopter or fixed-wing aircraft. This proposal is an attempt to ameliorate limited resources by bringing all available patient information to ambulance clinicians interacting with patients. The value of pertinent medical history is paramount when giving a differential diagnosis of a particular patient’s current signs and symptoms.

Currently this valuable resource is unavailable during transport medicine due to lack of communications technology providing interoperability among healthcare systems of various institutions.

3.3 IFT Profile

The IFT profile provides a portion of the PCC technical framework that will address this deficit in HIT. We identified standards by consulting the HL7, W3C and ISO frameworks and developed case studies as the basis for our IFT profile. Thus, the actors are defined, functions and transactions are specified to manage interoperability between hospitals and the ambulance.

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

3.3.1 Use Case 1

A 47 year old white male patient visits his Primary Care Physician (PCP) complaining of recent chest pain. During his visit the PCP obtains an EKG which shows significant changes in multiple leads. The 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 to update the record during the transport. Upon arrival at the local Emergency Department (ED), the 911 providers provide this updated information to the ED.

3.3.2 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 pertinent records is limited to providing a CD containing 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 the cross community access (XCA) protocol, the transport staff is able to obtain limited information. They continue to update the EMR locally during the transport for near real-time viewing by the receiving facility. Upon arrival they are able to 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 shared content. Each actor can implement a view, document import and has the options of importing sections of pertinent files or a variety of discreet data. These imports allow specific parts of the EMR to be modified.

The IFT profile configures 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 so as 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 cross-enterprise document sharing (XDS) document entry repository unique ID. This can also be an XCA 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.

We've identified the necessary functions that each stakeholder needs to provide for transport medicine. While the focus is clinical management of the acutely ill patient, support personnel also 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 defining transactions that occur among 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 often are not reported or are thought of as part of the normal workflow and thus not usefully differentiated [16].

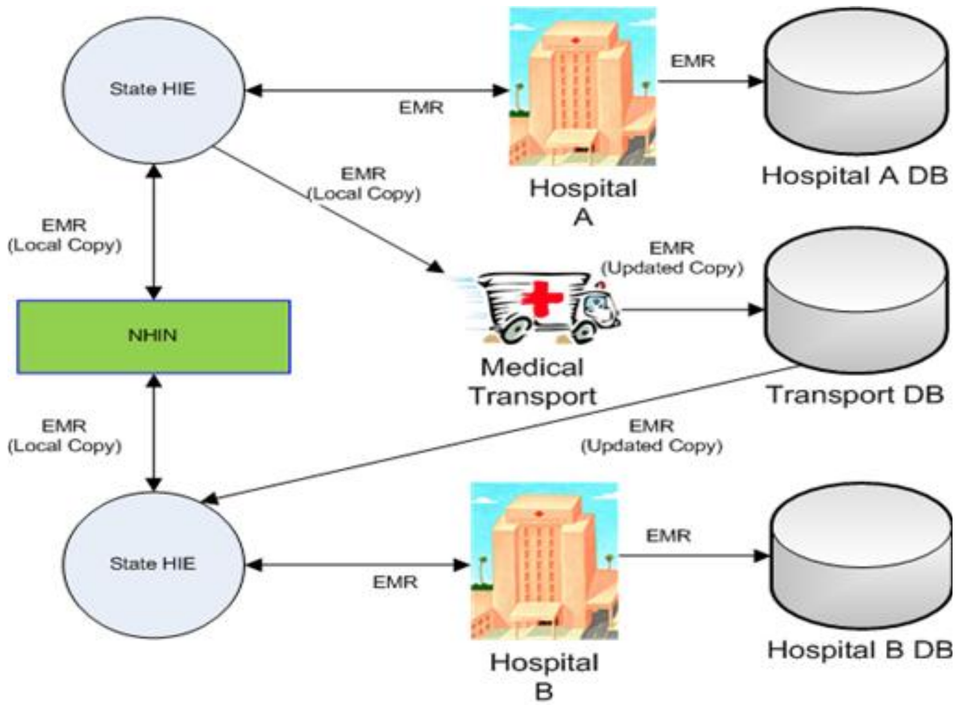

Figure 12. EHR Transmission over HTTP requests using SOAP envelopes with ebXML messages

3.4 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 needed information. The ability to retrieve accurate and current patient records might occur during travel to the sending facility or even at the patient's bedside. The gathered information would then be updated by onboard 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 it and store a local copy as shown in Figure 12. These networks are being established to support 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 to provide communication using ebXML. These discharge and transfer triggers, respectively referred to as 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

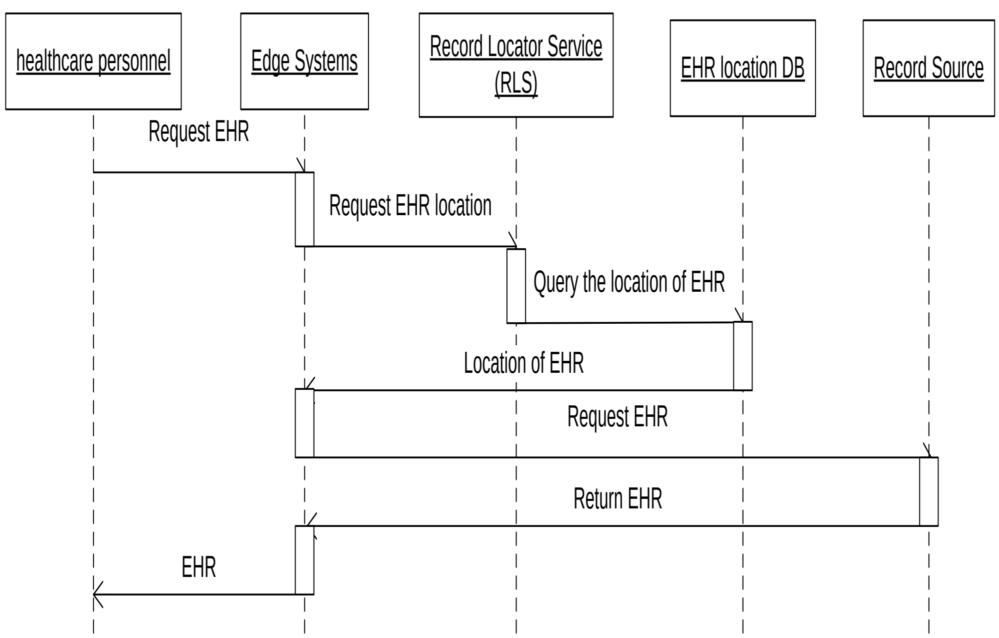

Figure 13. RLS Sequence Diagram

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 receives these messages in their systems, the GUI displays the patient information and provides the ability to GET their chart.

3.5 The Approach

Our approach supports federal mandated standards for electronic medical records. While the majority of the HIT world focuses on major healthcare functions, there has, as we have noted, been little attention paid to 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; we provide the appropriate road map to accomplish optimal goals. After validation by the IHE, our profile will become the basis for application development in the medical transport industry. The National Emergency Medical Services Information System consortium has begun standardizing a data dictionary [13]; but our framework provides the interoperability of such a data dictionary using ebXML [6] Registry Standards, SOAP [18].

ebXML was originally created for e-commerce to support large repositories of information cataloged in a registry service. This same fundamental solution can be utilized in healthcare and will be the backbone of the record locator system (RLS) seen in Figure 13. Our RLS system identifies the location of the actual health record document inside the HIE. ebXML was

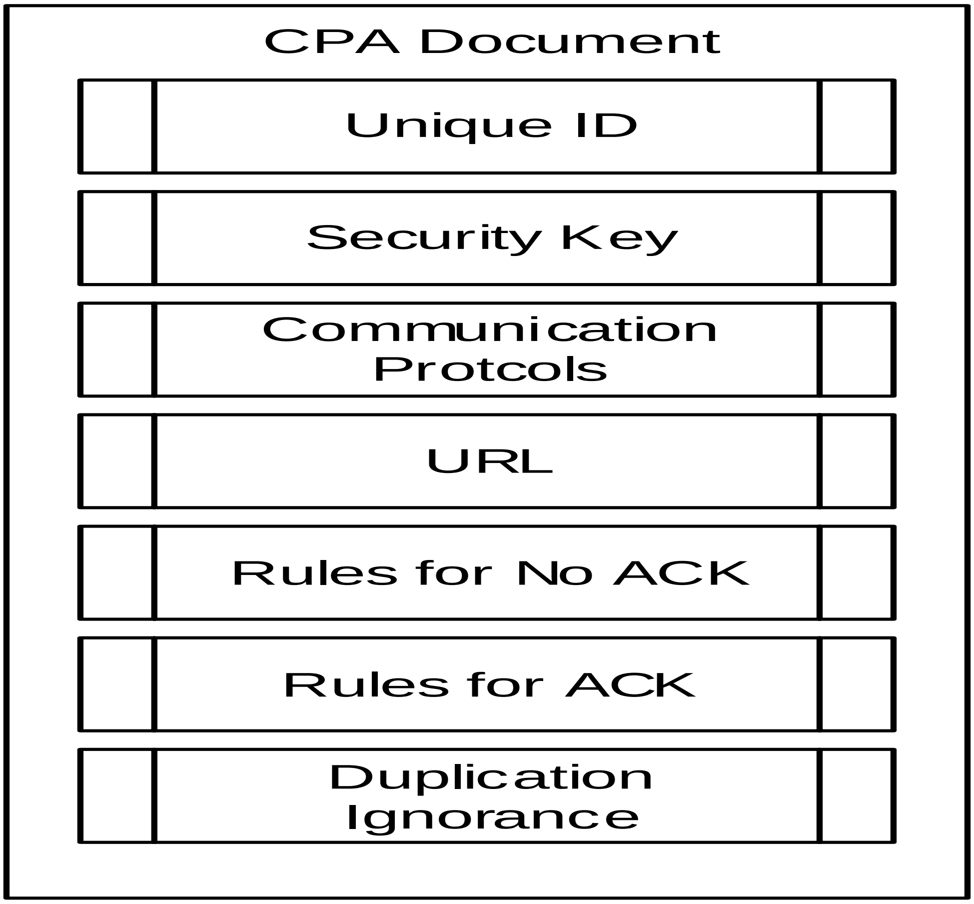

Figure 14. CPA Document

created so that multiple partners would be able to communicate by means of the global use of electronic business technology in an interoperable and secure manner.

This capability has already been realized in the financial world where trading partners use unique trading profiles that describe their abilities. During interactions a CPA document describes a relationship as seen in Figure 14.

Similarly, 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. The 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 15.

These transactions will be authenticated using a SAML token. This procedure 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

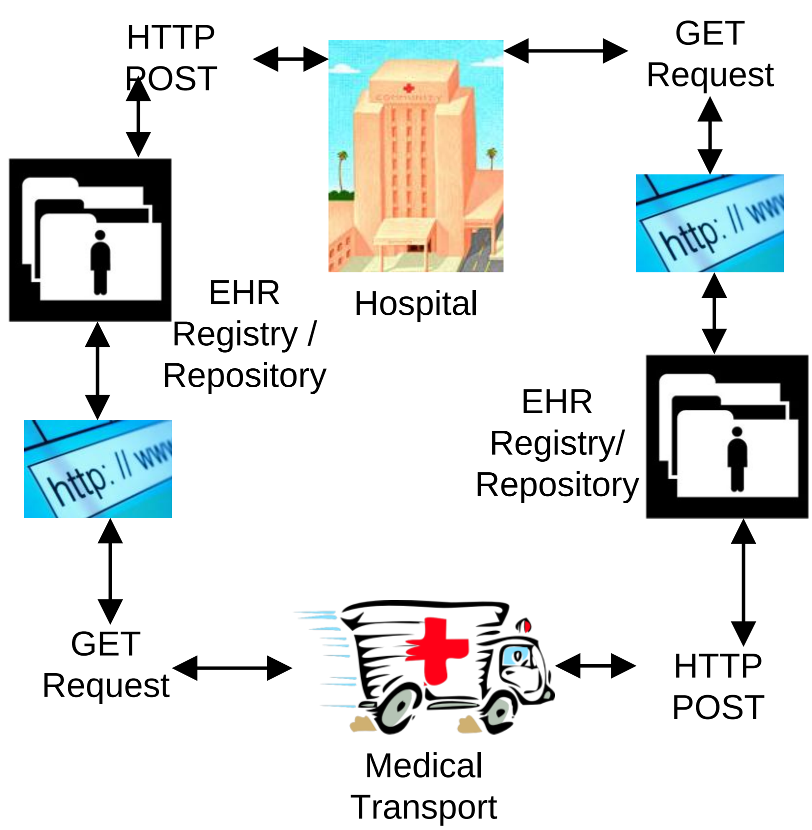

Figure 15. IFT Profile Interoperability

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 [34]. This transport team named “Lifeline,” which was involved in our study, transports a broad range of patients between ICUs and procedure areas inside the hospital as well as outside the hospital using ground and aero medical transport vehicles. The Lifeline transport team will use implemented software which supports the IFT profile. Feedback provided by both clinicians and supporting personnel 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 data, vital sign observations and any interventions required during transport along 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 as a system that submits documents and metadata. Another involved actor is defined as the *document repository*; its role is to provide a storage system and

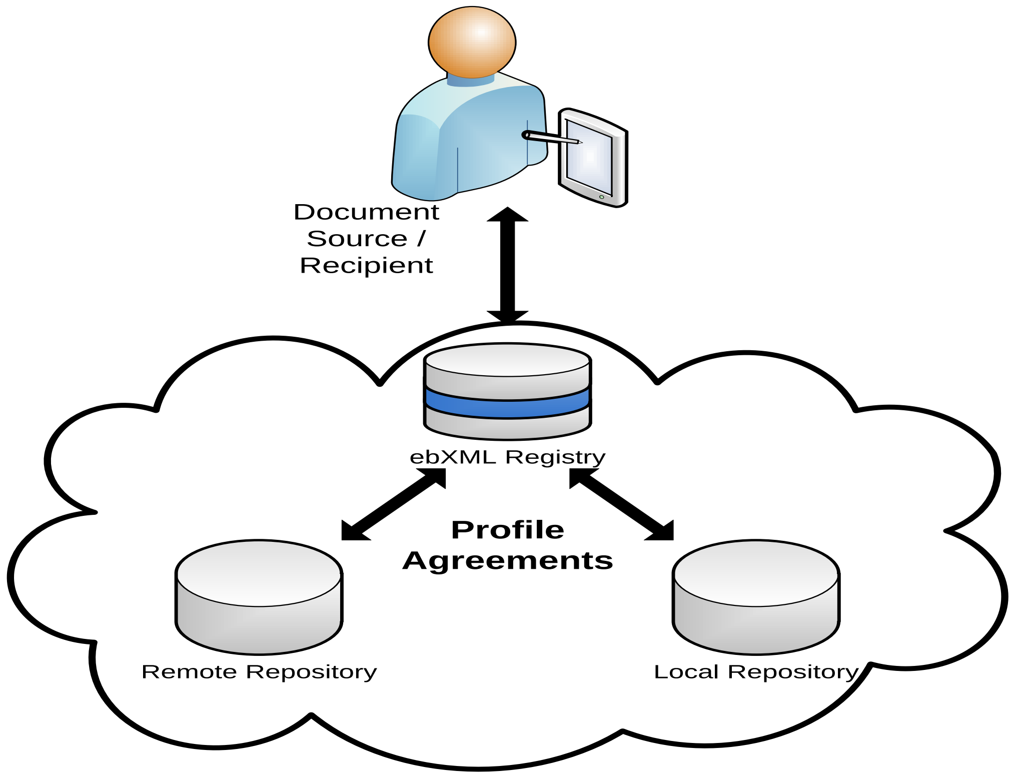

Figure 16. ebXML Architecture

forward pertinent metadata to a document registry for future query. Finally, an actor defined as a *document recipient* 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 16.

This messaging system uses an asynchronous message and response configuration. 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, the ebXML Registry Message. This will include all pertinent documents 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 date/time stamp, MIME indicator and SOAPAction: “ebXML” are also included.

The email contains a header and body. The header contains information expressed in ebXML data elements. These include eb:From, eb:To, eb:CPAId, eb:Action (submit objects), eb:MessageID, eb:Description, and optionally eb:AckRequested. In addition, a way to link references to documents and their appropriate identifiers would use a document identification system. This reference is to documents attached 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 a way to update those documents for real-time viewing by the receiving healthcare team, creating a virtual patient.

Chapter 4
Enterprise Architecture in Healthcare Interoperability

4.1 What is Interoperability

Interoperability defined by HL7 [42] 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 [31]. By reverse engineering this process, this type of interoperability shows how its shared data can support the specific activities of the organization and how it can integrate the data into their current system. Figure 17 shows how interoperability affects a single organization.

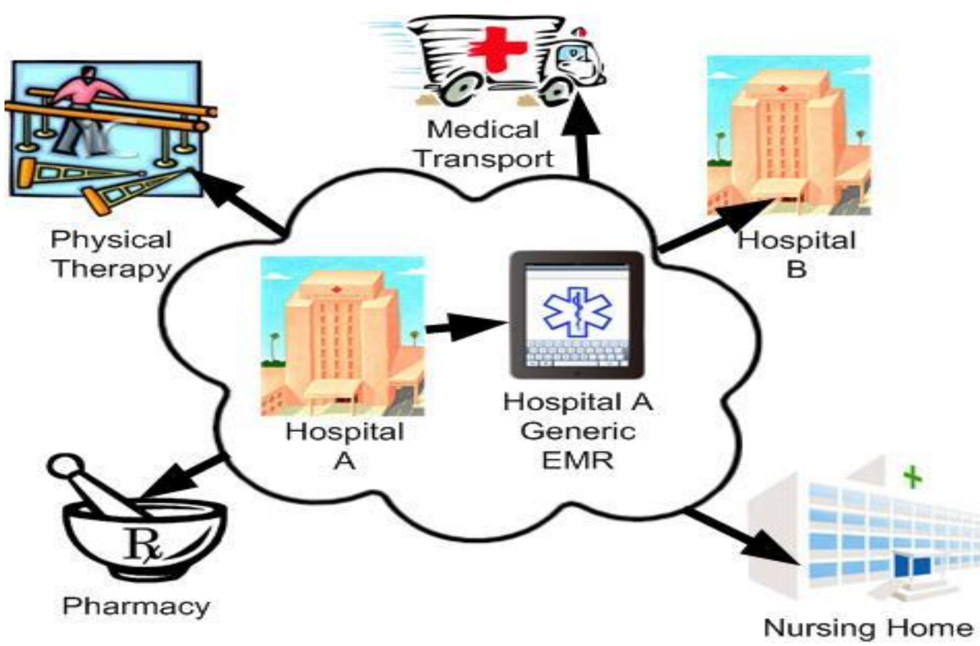

Figure 17. Organizational Interoperability Integration

The organization needs to be able to produce data that is useful to other organizations also. The data, termed generic in Figure 17, are presented in a format that can be effectively used and integrated into other organizations. Many organizations are still struggling with implementing the integration, tackling more involved steps only to bring even more confusion.

4.2 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, which is typically modeled in four sub-architectures: Business, Data, Applications, and Technology [43]. The Federal Enterprise Architecture Framework (FEAF) provides a common methodology for IT acquisition, use, and disposal in the Federal government [44]. 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 [45]. 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 as well as governance, organizational and management sub-processes [46]. 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 the former category. 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 by them [47].

4.2.1 TOGAF Interoperability

The first mention of interoperability in TOGAF occurs during the Business Architecture (Phase B). The Business Information Interoperability

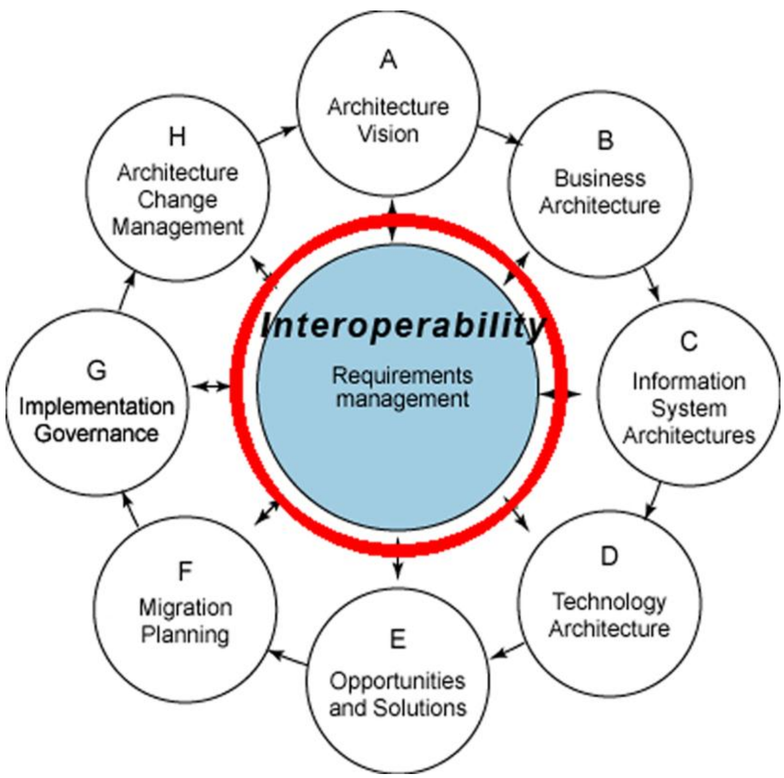

Figure 18. TOGAF Interoperability Element Encompasses All Aspects of TOGAF Methodology

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 that keep in accordance with the enterprise technical standards. There can be no interoperability conflicts among the matrices 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 18 shows a comprehensive approach for 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.

4.2.2 FEA Interoperability

There are many unique characteristics of federal architecture which separates it from commercial counterparts [48]. 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 in order to prevent fragmentation and a lack of semantic interoperability. Figure 19 shows where interoperability needs to be created as its own beginning architectural segment, but then encompass all the work products from implementing FEA.

4.2.3 Zachman Interoperability

The Zachman Framework, originally known as the 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 [45] (e.g., textual, graphical). According to Zachman [49], it may not be possible to implement fundamental changes 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 will get transmitted. This could impact patient safety if the pharmacy has information regarding previously prescribed

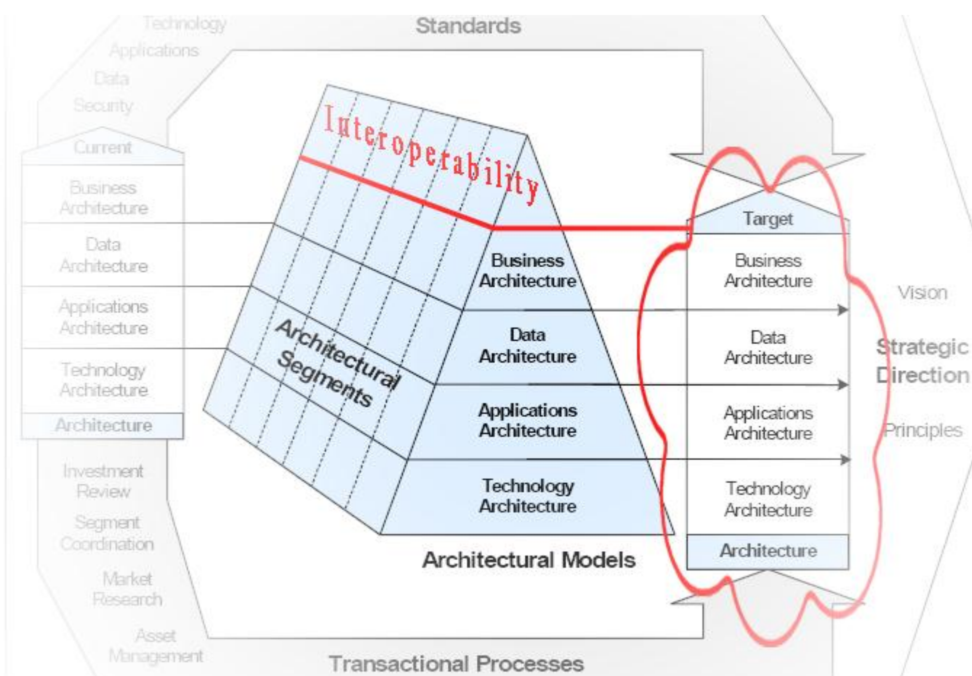

Figure 19. FEA Interoperability Solution

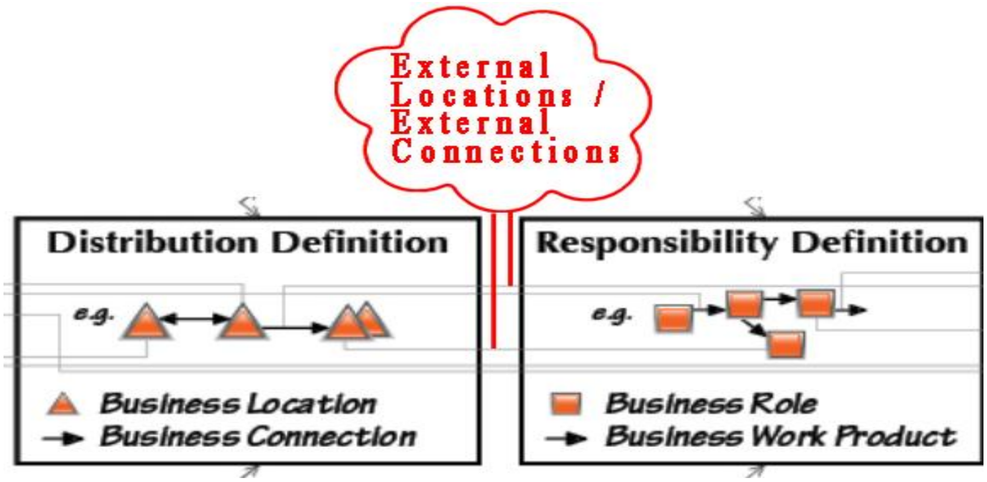

Figure 20. Zachman Interoperability Insert from Zachman Framework

medications that may interact with the current prescription. This patch approach could reduce flexibility, since heterogeneous means optimize the parts are itemized at the expense of the whole and interoperability means the whole is optimized at the expense of the parts [49]. 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 establishing the connection in the gap between business location and role as shown in Figure 20. By examining external locations and their connections, we'd like to implement interoperability.

4.2.4 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 effectively placed in a position to integrate interoperability from the beginning of the EA plan.

4.3 The First EA Interoperability Phase

Technical interoperability progress has been remarkable, featuring many mature solutions. But convincing organizations to change their workflow to accept a universal data element that will have impact across multiple organizations is difficult. Integrating 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 [50]. 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 your business processes. With this self-centered goal, it can be difficult to work with the goals of other organizations, including competitors to provide optimal patient care. A hospital does not merely treat a patient; it provides a full service experience. There are multiple services available to the patient and other caregivers. Knowing who all of these stakeholders are and asking what can be done to keep them satisfied is absolutely necessary. The same outside the box thinking is what needs to be accomplished during the initial phase of an EA endeavor.

4.3.1 Establishing External Stakeholders

External stakeholders need to be assessed. These are the ones that stand to gain an advantage from the information to be shared and those whose information we want to use. We stand to gain far more if such relationships are effectively managed and established. First, the customer will appreciate our ability to create a seamless relationship with organizations that might also provide service, sometimes the same service. Our results demonstrate a better understanding of the global business process when relationships with external stakeholders are established. During the initial IHE profile phase external stakeholders were left out. It was only then we realized that smaller hospitals might require document sharing using less technical methods, such as by email or portable media that we included them in our process. So we stand to gain a lot by thinking outside the box and including external stakeholders in our list as shown in Figure 21.

4.3.2 Determine Architectural Interoperability Constraints

It is necessary to analyze the business principles of stakeholders

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 21. Sample External Stakeholder Map Matrix

identified in section A. If an institution typically functions on a team-based approach to medicine and outlying facilities are staffed with single clinicians due to budget constraints, then it cannot be assumed that a single practitioner will be expert in all differential data produced by a clinical team consisting of anesthesiologists, pathologists, neurologists and critical care medical specialists. Recognizing this and many other constraints crucial if an end goal is to be able to share semantic information with those external entities. A sample architectural principle of an external pharmacy stakeholder is shown in Figure 22. These principles need to cover major realms including Business, Data, Application and Technology architectures.

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 22. Architectural Interoperability Principle

4.3.3 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 enterprise will fail. The interoperability map show in Figure 23 highlights the required focus areas.

4.3.4 Determine Architectural Interoperability Budgets

Budgets were not part of our research, but it is justifiable to mention collaborative efforts and funding on behalf of both the organization and

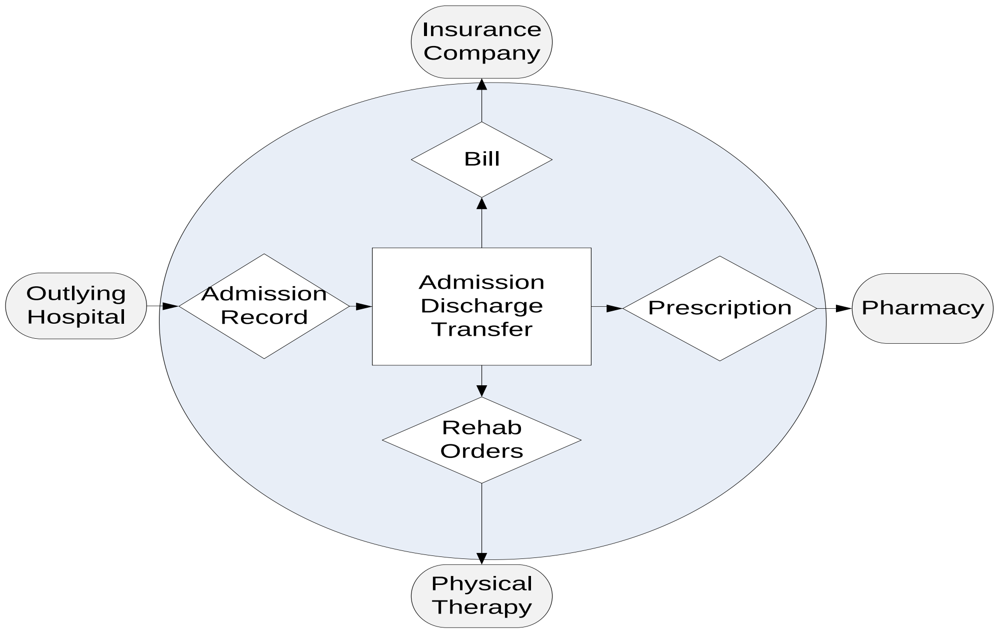

Figure 23. Interoperability Map

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. We must consider cost sharing when developing an architectural solution that will benefit the external stakeholder as well.

4.4 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 effective 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 are all essential.

4.4.1 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 [51]. This does not refer to reusability and duplication of processes already completed, but rather focusing on what you need to achieve. Our 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 processes are necessary in order 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 this must include acknowledgement of the existence of specialized services, known practitioners, accepted insurance or some other reason that is making the patient in question desire to 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 proceed to examine another layer.

4.4.2 The Interoperability Layer

We can continue to dissect the business footprint by adding an interoperability layer shown in Figure 24.

This layer shows the relationship between business services and integral external entities. There are many points of integration inside a hospital and just as many points for interoperability outside the hospital. Hospitals might contract unique work out to third party vendors, such as radiology services. External Resources need to be able to interoperate with the referring organizations. This is also true of business relationships with specialists. It becomes clear how important effective interoperability is to a healthcare organization and others as well.

Figure 24 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 that need to be taken into account for an effective interoperability layer. Since information is shared among external

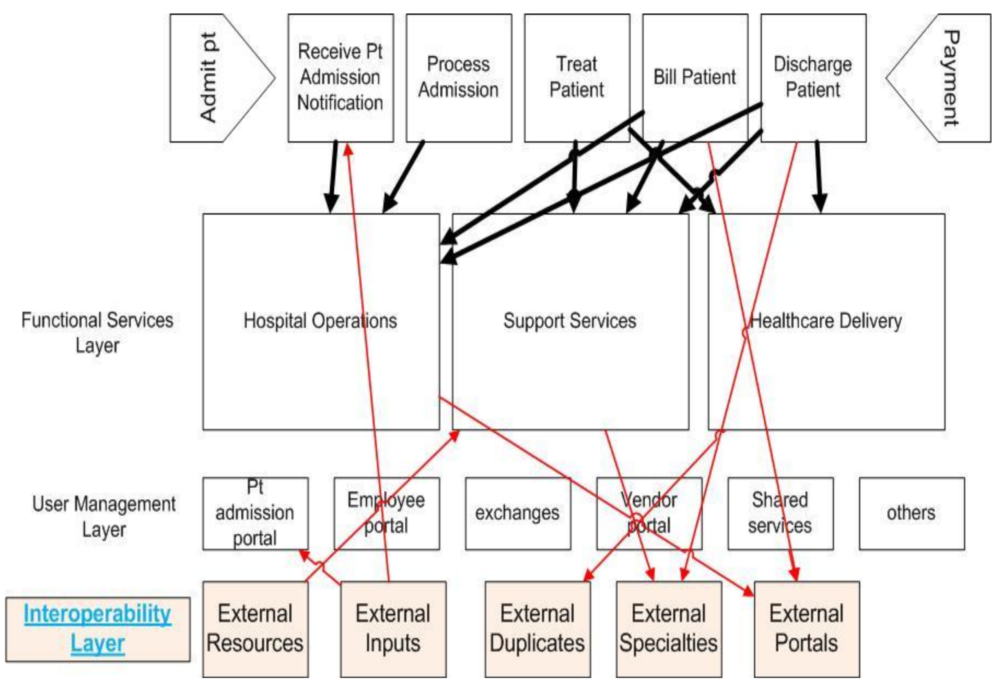

Figure 24. Interoperability Layer

entities so often, it is pertinent to rethink business strategy with external stakeholders in mind.

4.4.3 Gap Analysis

Every framework suggests doing a gap analysis; this is the clear cut way of showing where we need to create new interoperable building blocks. No framework addresses gaps 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 tasked with 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 for transport within these contexts.

4.5 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 explain how an entity might organize their data for all types of medical transports. This profile leverages current standards such as HL7 and LOINC to implement interoperability in the context of existing common hospital practices and 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 [52].

The creation of a National Health Information Network (NHIN) and a local Health Information Exchange (HIE) assists 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.

4.6 Trial Work

The EA interoperability process was used when developing the IHE supplement profile referred to in Chapter 3. The profile was developed during the 2011/2012 work cycle of the IHE. Initial face to face meetings occurred in October 2010 in which 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 and 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. Then 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 need to be involved in 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, in Appendix A: IHE Transport Record Summary Profile is the current version of the TRS Profile published for implementation by the healthcare IT community.

Chapter 5
Clinical Document Architecture Consolidation

5.1 Meaningful Use

In the American Recovery and Reinvestment Act, the US government details a staged approach to standardizing electronic health records. Only the first two stages have been released to date with the second only recently released. We focus on Meaningful Use stage one for our solution. There are 15 specific criteria for Meaningful Use stage one. These basic criteria include computerized medication order entry, drug-drug and drug-allergy check lists, generated and transmitted electronic prescriptions, and the ability to maintain medication, problem and allergy lists [53]. Many larger institutions have achieved some degree of meaningful use already through current systems; they can then decide if adding additional modules or starting from scratch is their best option. While larger institutions may have the financial status to achieve meaningful use, many smaller single physician practices are struggling to adopt an EHR system that meets the goals of meaningful use.

Consolidation of medical records during patient transport meets the following meaningful use stage one objectives:

- Maintenance of medication, problem and allergy lists.
- Documentation of vital signs
- A medical summary of the encounter with the transport unit
- Information exchange to other providers.

5.2 Process development

We decomposed each aspect of the interoperable health information exchange processes into four subgroups: business process, information process, application process and technical process. These scenarios describe the necessary components for determining how and what aspects of a patient's health information to retrieve during transport.

5.2.1 Business Scenario

Figure 25 shows the proposed business process model. The darker colored sections indicate where changes have been made to the current

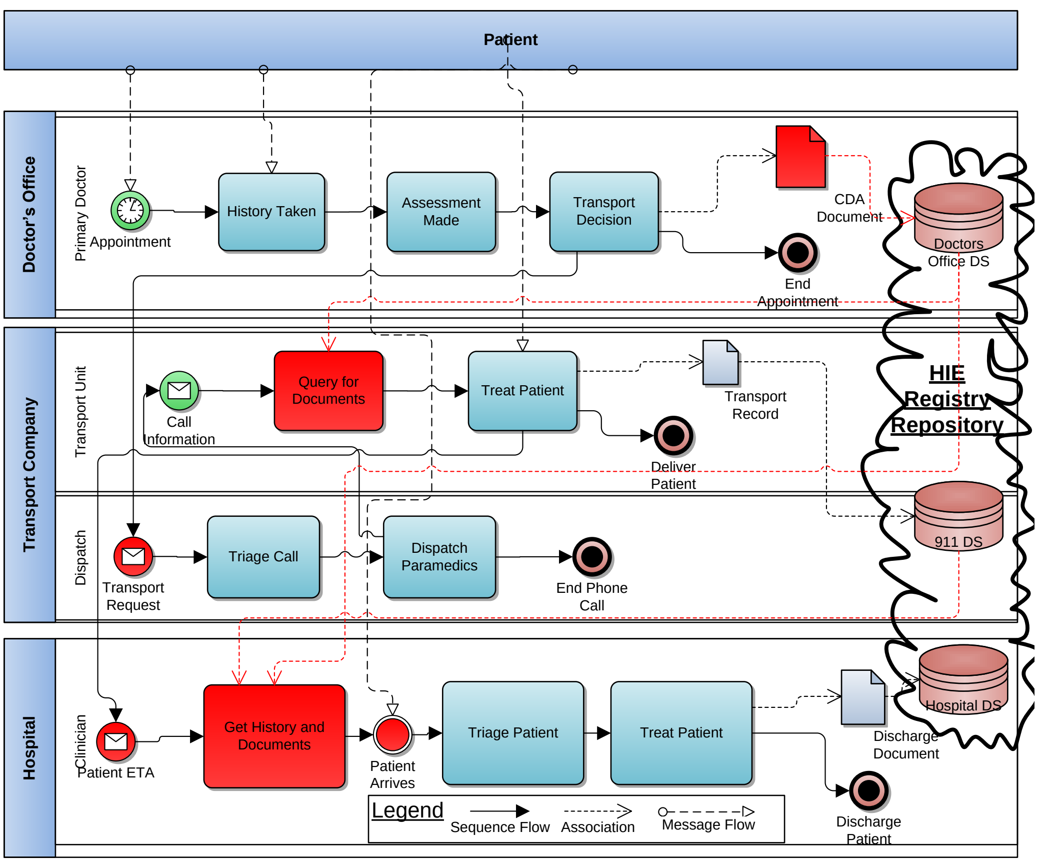

Figure 25. Proposed Medical Transport Business Process Model

process. The doctor creates a medical summary document based on the current visit and stores it in his office on their local data store that participates in the state health information exchange (HIE). A transport request is made by the doctor to 911. The transport clinicians are now able to query the HIE for any relevant documents about this patient. The transport unit creates a transport record and stores it in their local data store which also participates in the HIE. The transport unit also updates the destination hospital with ETA. Upon notification, the hospital team can query for records that include both the doctor's office visit medical summary and the Transport Record Summary (TRS) which we previously developed [50]. They are then able to begin treatment and also determine the appropriate care plan for this patient upon arrival, which may include an additional subsequent medical transport to a facility configured to provide a higher level of care.

5.2.2 Information Scenario

Information during a patient visit is compiled into a medical summary XML document. When the document is stored, the type of document and patient identifiers are updated in the HIE registry. Steel's ontology describes how messaging resources use on call type and location to dispatch a transport unit using EDXL Sharp [54]. The transport unit then queries the HIE for information.

During this process relevant information about the patient is gathered. The goal is to provide pertinent medical history that can assist clinicians onboard the transport with the current problem. A semantic search will produce these results based on current factors and additional medical coding available in all documents. It is formatted into a single XML document that eliminates redundancies while highlighting areas of concerns based on current patient conditions and past medical histories. The transport unit also interacts with the patient and updates the local data store with a TRS document. The receiving hospital is electronically notified about the incoming patient. This notification allows the hospital to access all available documents.

5.2.3 Application Scenario

The doctor's office can view the Personal Health Record for updated information through their electronic health record (EHR) system. This system also allows creation of continuity of care documents. Two applications are in use during the medical transport: Computer Aided Dispatch (CAD) and an EHR. The calls are triaged by dispatch by entering details gathered during the phone call as well as location information which can be acquired through the Enhanced 911 (E911). Implemented following the events of "9/11," this

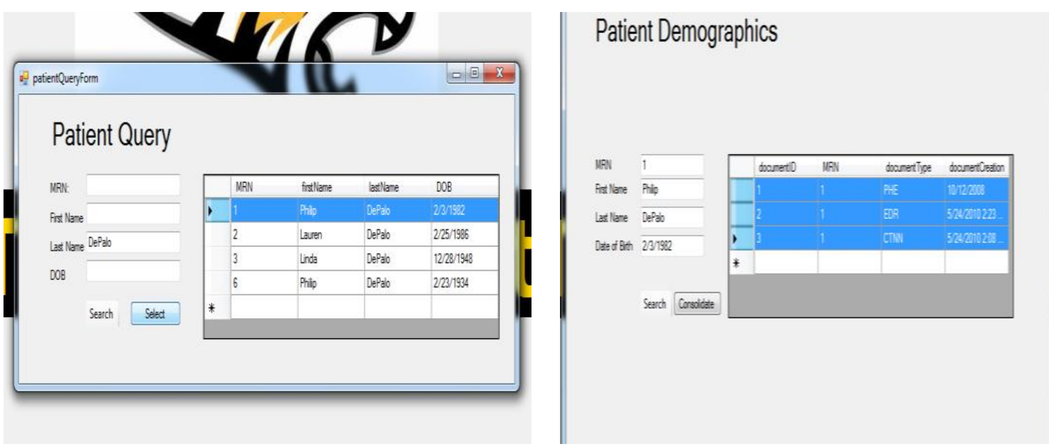

Figure 26. Transport Application Interface Screenshots

communications technology permits emergency response personnel to pinpoint the location of a cellular telephone caller anywhere in the United States [55]. The CAD determines the closest and appropriate level of transport unit.

The transport unit has an EHR system which will access the HIE and produce a single document, by consolidating CDA documents, comprising of all relevant information based on a semantic search. An example of such a system is shown in Figure 26. This EHR will also update the HIE with a new TRS document based on the care provided.

5.2.4 Technical Scenario

Figure 27 shows the applicable software architecture along with the posted and retrieved documents. The client application interface is used to

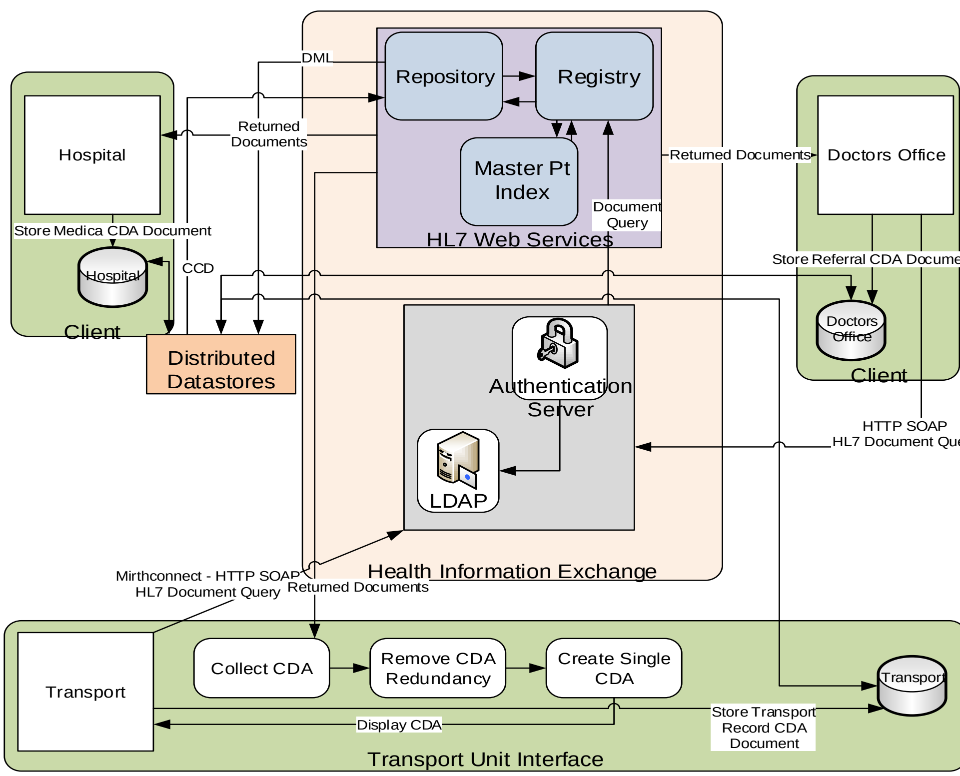

Figure 27. Interoperable Transport Architecture

interact with the HIE. There are multiple ways Health Level Seven (HL7) messages can be specified. The transport interface has the ability to use client or server side connections such as HTTP [56] and "mirthconnect" [57] as an interface engine. The HTTP can be broken down into HTTP headers and bodies. Packaging can be handled through a SOAP envelope. The doctor's office can make an HTTP SOAP message request for an available documents based on the patient's history or update made in the PHR [58].

We propose a module within the transport units EHR that collects the queried CDA documents, strips each document of redundancy, based on XML tags, ICD Codes, and other recognized standards, and creates a single CDA document with relevant information about the transported patient.

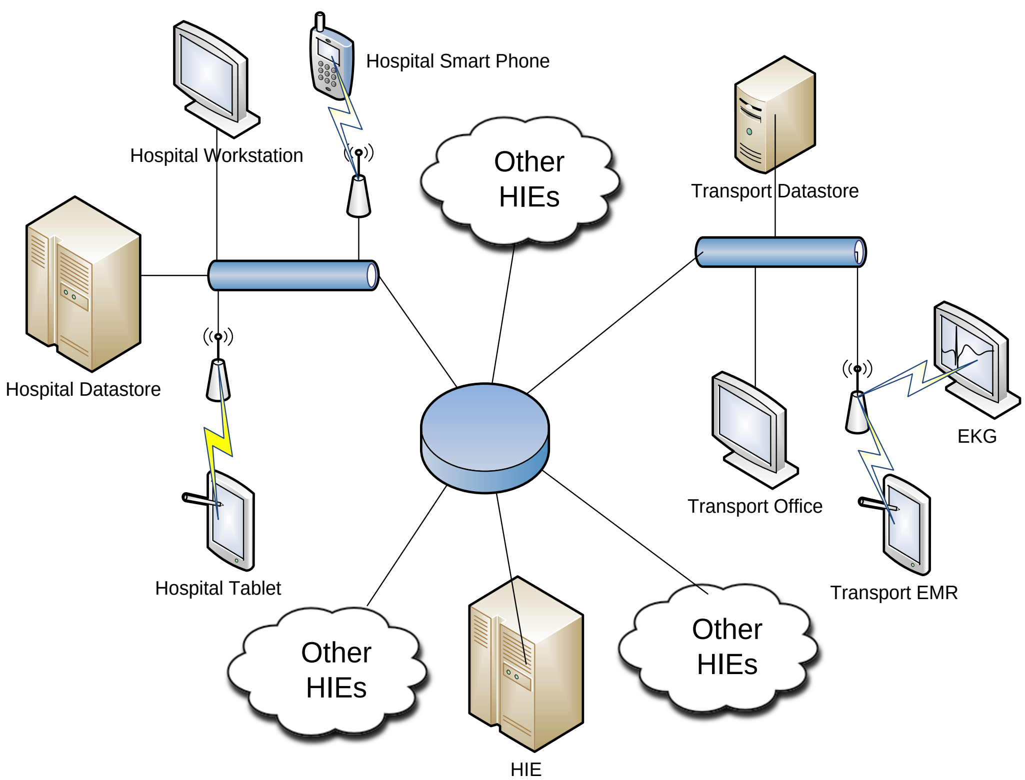

Figure 28. Network Model

Chiu describes standards used in global e-commerce, with trade agreements stored as documents between business entities; this registry and repository concept can be applied to healthcare information technology [59]. The standard is called Cross Enterprise Document Sharing (XDS). The goal is for a healthcare institution or entity to be able to provide and register an HL7 continuity of care document set [60]. The clinical documents are organized into three levels: the narrative documents, section level content, entries for unique coding and semantics [61]. The documents are provided to the repository and then the repository is asked to register them with the registry. This request must contain the metadata describing the documents, at least one object per document, a link to the new documents and references to existing documents. If the request does not transmit, the repository will send an error.

Figure 28 shows that data collection starts at the personal medical environment of patient monitoring devices such as an EKG. These can be connected via USB or Bluetooth methods or even low powered local area networks such as ZigBee Health [62]. Aside from the connection of local monitoring devices, the transport unit would use Wide Area Networks technologies such as Cellular GPRS, EDGE, 3G/4G and WiFi. Wired networks such as Ethernet or DSL are less functional, given the mobile environment of the service.

Databases can consist of MSSQL servers and messages that, between these doctor/hospital systems, are handled through Message Oriented Middleware (MOM). MOM allows applications to talk over different systems and network protocols which would be encountered when moving between systems. Applications would typically run on computer equipment designed for a rough environment. These devices are manufactured to withstand the rugged environments where patients may be picked up as well as interfacility transport by providing waterproof, impact proof and drop proof systems.

5.3 CDA Document Consolidation

A CDA document is an XML-based clinical document standard to be exchanged across health care community [60], [63], [64]. The HL7 CDA is a document markup standard that specifies the structure and semantics of a clinical document (such as a discharge summary, progress note or procedure report) for the purpose of exchange [60]. The CDA scheme provides the healthcare interoperability by presenting syntactic standard of clinical documents. Accordingly, the adoption of the CDA document results in enhancing healthcare information sharing and decreasing interface burdens across the related parties.

Generally, CDA documents are too complex and huge for emergency medical workers to check all the scattered medical information from multiple documents while transporting a patient in emergency situation. Given the limited amount of time a transport unit has with a patient and the time critical interventions that must be performed, viewing each CDA document is not realistic.

We propose creating a single CDA document for the patient by consolidating available CDA documents through the HIE search of all available documents presented to the transport unit. Upon receiving the list of available documents on the transport unit EHR, the proposed mechanism will search each document for redundancies based on the specific XML tags, remove redundancies, reformat each component with unique information found in each document, and present the single CDA document as described in Figure 29. These documents will not be stored within the HIE, but the function will be used as a reference tool for any time critical document query. This CDA document may be used to create a new TRS document for the transport unit. Template IDs and code systems will not be changed from their original format, but the new document will be saved in new data storage called Transport CDA data store (DS) as shown in Figure 30.

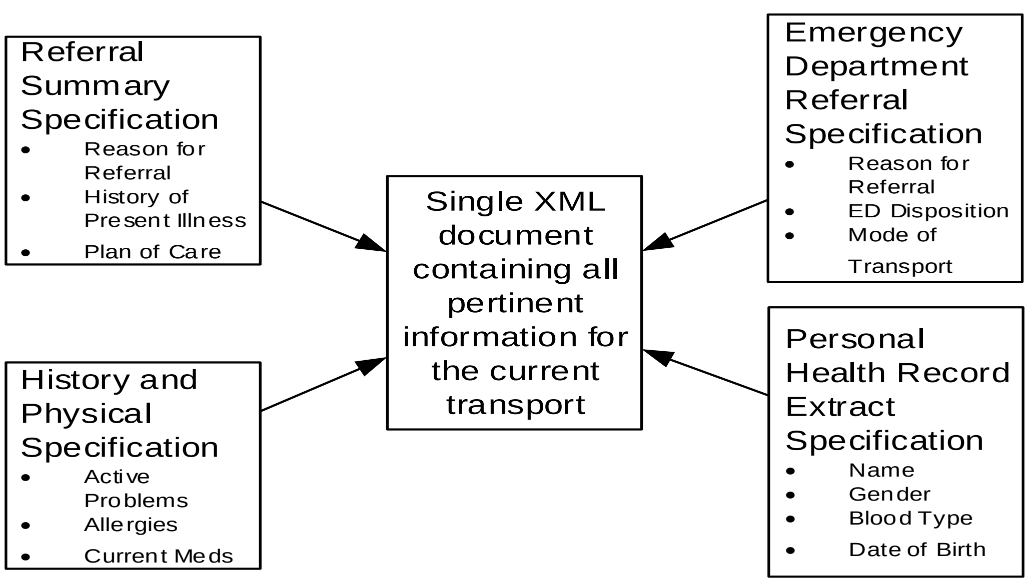

Figure 29. CDA Document Consolidation

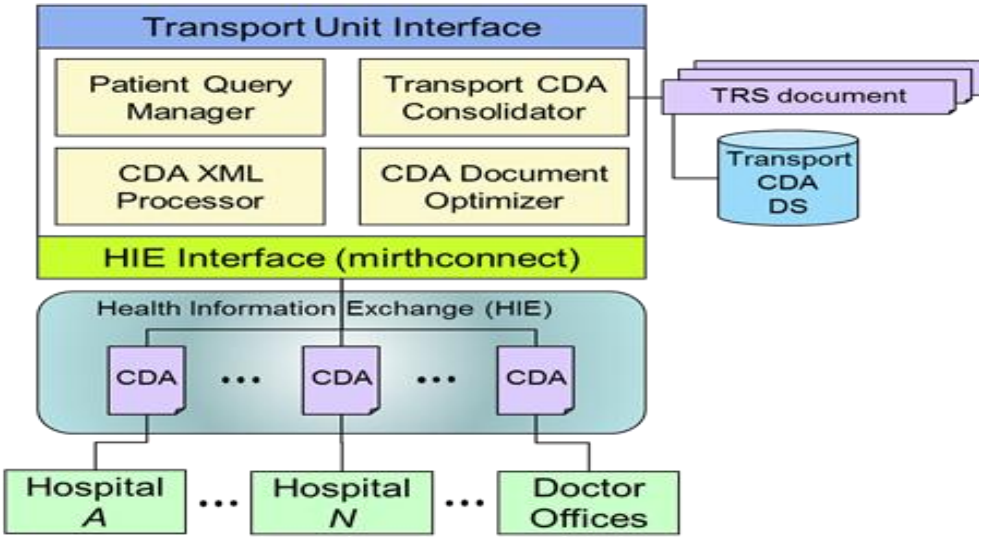

Figure 30. TRS Constructor with CDA Consolidation

5.3.1 TRS Constructor

The TRS constructor module is composed of a patient query manager, a CDA XML processor, a transport CDA consolidator, and a CDA document optimizer. A TRS constructor module is installed in a transport unit. It generates a TRS document after finding the patient's CDA documents and analyzing and optimizing the documents in order to create a pertinent TRS document.

The TRS constructor module provides a transport unit interface which includes a user authentication procedure which identifies a patient by his or her identifier and additional recognizable information such as birth date, address, race, etc. In addition, the CDA filtering function of the patient query manager provides extended search options like a symptom and keyword-based search and a semantic-based extended search.

XML-based CDA documents are decomposed by the CDA XML parser. Decomposed patient's health records are analyzed to extract appropriate patient records by the CDA semantic analyzer within CDA XML processor. The extracted records are filtered to remove redundant information by CDA document optimizer. The suggested optimization presents two options for generating both a preliminary CDA document based on the associated symptom and keyword analysis and extended CDA based on semantic analysis. The transport CDA consolidator organizes a new TRS document and provides the transport staff with the consolidated document through the transport unit interface. The TRS documents are stored in the transport CDA data store.

The TRS constructor searches for available CDA documents through an HIE interface which provides HIE connection that is implemented by applying “mirthconnect” [57], the open source HL7 healthcare integration engine.

5.3.2 CDA TRS Document

The following example shows a consolidated TRS CDA document written in XML:

```
<ClinicalDocument xmlns='urn:hl7-org:v3'>
  <typeId extension="POCD_HD000040"
   root="2.16.840.1.113883.1.3"/>
<templateId root='1.3.6.1.4.1.19376.1.5.3.1.1.1'/>
<templateId root='1.3.6.1.4.1.19376.1.5.3.1.1.2'/>
  <id root=' ' extension=' '/>
  <code code=' ' displayName=' '
   codeSystem='2.16.840.1.113883.6.1'
   codeSystemName='LOINC'/>
<title>Medical Summary</title>
  <effectiveTime value='20081004012005'/>
<confidentialityCode code='N' displayName='Normal'
    codeSystem='2.16.840.1.113883.5.25'
    codeSystemName='Confidentiality' />
```

Chapter 6
Improving Patient Care in Transport Medicine through an Ontological Approach

6.1 Healthcare Exchange Domain

In order to achieve interoperability among healthcare institutions and various government agencies, public health and private sector participants have organized standards that define a network of systems that will support the exchange of electronic health data. HealtheWay, formerly the national health information network, is an organized body of smaller HIEs. An HIE is a network of healthcare organizations such as hospitals, rehabilitation clinics, doctors' offices and laboratories that have agreed to participate in an exchange of records to support healthcare. These records are individual documents based on individual encounters with each of these organizations, the whole of which comprises a patient's EHR. Therefore an EHR is a conceptual single record about a patient's entire medical history, which consists of multiple documents from a variety of encounters. If each provider were to create their own proprietary document, the communication among providers would be problematic. HL7 has enforced a standardized set of rules to govern these documents and as such, the Clinical Document Architecture (CDA) [5] is the governing standard for electronic medical documents. The agreements or business relationships among organizations is based upon the ebXML standard for e-commerce.

6.1.1 ebXML

ebXML is comprised of multiple components: Business Process Models, Core Components, Messaging Services, Registry and Repository and Trading Partner Information. Business process models define the basic rules of specific transactions among trading partners. These rules are based upon simple business transactions such as a customer inquiring about an item, the seller providing the information and the price and finally the buyer agreeing to purchase the item. The resulting business process specification schema is part of the environment created for business collaboration [59]. Core Components are business objects. Objects define a real-world concept such as a customer. Objects are part of the building blocks of ebXML. Registry and repository concepts in ebXML are similar to a database. The registry is a listing of information that is stored in the repository. The registry allows for fast indexing without the need to access the actual data elements in order to direct an inquiry. Trading partner information is an electronic contract that defines interaction protocols. It does not contain any business information, but rather the technical system specifications.

6.1.2 The Registry

The registry in ebXML is a database of XML artifacts, schemas, data elements and metadata which are details about those artifacts. There are many benefits to using a registry. It does promote services discovery and maintenance of registered objects. It allows for fast indexing and queries for specific artifacts as well as enabling security and efficient control versions of artifacts. It provides availability and reuse of various artifacts. It allows for multiple users to improve current artifacts and submit new ones to be further enhanced.

The technology can be equally applicable to a registry in healthcare information technology. The standard is called Cross Enterprise Document Sharing (XDS). The goal is for a healthcare institution or entity to be able to provide and register a document set. The documents are provided to the repository and then the repository is asked to register them with the registry. At the same time, the documents may be provided directly to a document recipient. This request must contain the metadata, such as document type, provider, document ID, that describes the documents, at least one object per document, a link to the new documents and references to existing documents. If the request does not complete, the repository will send an error.

6.1.3 The Repository

Though discussed secondly, the repository is actually the gateway to storing documents and initiating the storage of information about those documents, the metadata. A request to store a document is sent to the repository and the repository then will update the registry with information. More transactions requests will hit the registry, but it will be the repository that enables the registry to have a reason to exist. There is no need to store information about documents that do not exist. Once the information is stored, then the registry can provide multiple users with much information about any patient that is queried. The goal of the repository is to act as the heavy hitter storing the large files for use in patient records as seen in Figure 31.

6.2 Ontology

Ontology is a specification of a conceptualization, that is, it's a description of its context and the relationships that can exist between different objects within its structure [65]. Semantic interoperability focuses on the relevance of the transmitted information to both organizations. If an organization sends data that is relevant to them, but that has no meaning for the

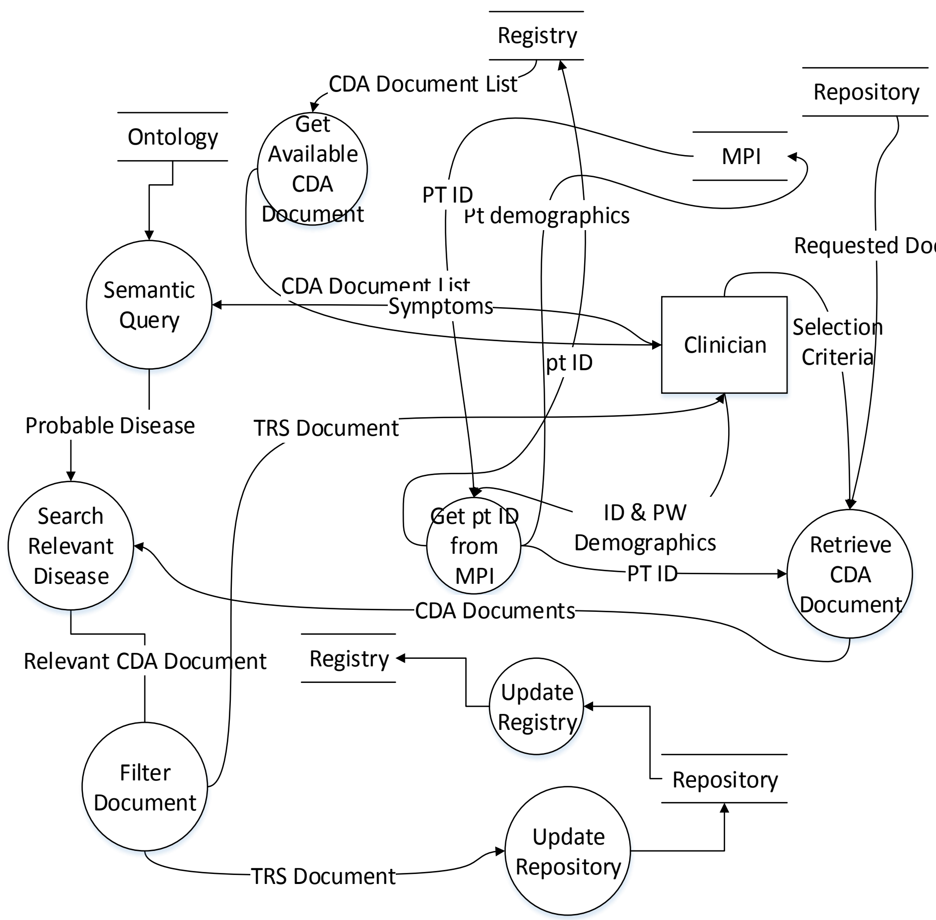

Figure 31. Transport Messages

recipient, then it is not interoperable [66].

Semantic interoperability will provide unique queries among multiple diverse data sources. The results of these queries will provide useful information that may not have otherwise been located due to the time constraints of patient transport. Very little time is spent with the patient during an emergency transport. During this time focus is on diagnosis and emergency intervention. Using unique query results that are based on the patient's own available medical history is an intelligent way to make the most of the limited time available. This information can prove the difference between similar medical issues that require significant different treatments. Currently a patient transported by 911 receives immediate care for their chief complaint, but previous medical problems are unavailable and not considered. A semantic query for this information could provide essential medical records of previously documented problems, allergies and medications that could prove lifesaving to an unresponsive individual without a spokesperson. Given the resource poor, time constrained environment surrounding 911 emergencies, queries that utilize logic to quickly and usefully produce results are paramount. Existing communications technology used in transport medicine does not provide the ability to exchange health information and can hinder essential care.

6.2.1 Semantic Interoperability

In order to achieve semantic interoperability of electronic medical records in transport medicine, we researched the basis of the resource description framework (RDF). RDF is the basis for the semantic web ontology.

RDF decomposes any knowledge into smaller pieces called triples [67]. To make the relationship between elements as meaningful as possible, we determine the level of detail for each triple. The more detailed this information becomes, the more useful the ontology. For instance *heart problems* are not detailed enough. This term can be broken further down into myocardial infarction, congestive heart failure, cardiomyopathy, etc. Figure 31 details the process flow of information through a semantic query of CDA documents. The clinicians must first provide demographic information about the patient so that their ID can be discovered from the Master Patient Index (MPI). The MPI stores multiple IDs for patients and is able to cross reference institution specific IDs for each patient based on demographic information. With this ID, we are able to query a list of available CDA documents and eventually choose the CDA documents we want to search. The patient's symptoms are then processed against our medical ontology described in a web ontology language (OWL) file. This ontology associates symptoms with possible diagnoses. Then based on the type of symptoms, it implies a confidence level to the most likely differential diagnosis for the current patient. These differential diagnoses are returned and a search is made on the list of CDA documents for those specific sections that relate to past medical history. A single XML file called the Transport Record Summary (TRS) is created along with a list of the probable diseases in situations where there is no relevant past medical history. This CDA consolidation using the TRS constructor and decisions support system accelerates the time to treatment for the clinicians [68]. The TRS constructor decomposes CDA documents by the XML parser and these decomposed documents have specific sections extracted using the semantic analyzer technology explained later in Figure 40.

6.2.2 RDF Triples

Our resource is here: http://www.lifelinetransports.org/Transports/patient#info. This is shown in Figure 32. The details of our message state there is a person identified by the above resource whose name is John Doe whose location is Johns Hopkins whose transport method is an ambulance. We break down this information into the RDF subject, predicate and object. Our subject is our resource URI; our objects are John Doe, Symptoms and ambulance. The predicates that describe those objects are: whose name is, whose symptoms are and whose transport method is. The subject's type is described by the World Wide Web Consortium (W3C) as http://www.w3.org/1999/02/22-rdf-syntax-ns#type, which is a person. We then form the RDF Triples. The RDF triple use a URI to describe the unique objects and then shows a relationship between things as well as the two ends of the link. Since HL7 messages ultimately are described by XML and specifically ebXML constructs, we convert the above RDF triples into RDF/XML in order to be exchanged, stored, etc. Our conversion of RDF to RDF/XML is shown in Figure 33.

http://www.lifelinetransports.org/Transports/patient#info,
http://www.lifelinetransports.org/Transports/patient#fullName, "John Doe"

http://www.lifelinetransports.org/Transports/patient#info,
http://www.lifelinetransports.org/Transports/patient#symptoms, "Chest Pain, Bradycardia, Chest Discomfort "

http://www.lifelinetransports.org/Transports/patient#info,
http://www.lifelinetransports.org/Transports/patient#transportMethod, "Ambulance"

http://www.lifelinetransports.org/Transports/patient#info,
http://www.w3.org/1999/02/22-rdf-syntax-ns#type,
http://www.lifelinetransports.org/Transports/patient#person

Figure 32. RDF Triples

6.2.3 Querying RDF graphs

With our data now defined using RDF, we use SPARQL Protocol and RDF Query Language (SPARQL), a recursive acronym. SPARQL allows us to query and retrieve data from RDF graph formats as previously described. SPARQL can query disparate data sources, which in healthcare is an excellent benefit. The ability to query records from multiple healthcare sources is invaluable to obtaining the most relevant information about a patient. In our example, we can query for the specific name of a patient across multiple transport requests based on the location of the request as seen in Figure 34. Another example would be to query a specific set or all sets of medical records across all healthcare institutions based on a single patient identifier. The next logical step in our example would be to query information about the specific patient identified from the first query using only the healthcare institution requesting the transport and the timestamp on the patient's current admission to the requesting institution. This would provide the transport unit with only the

```
<?xml version="1.0" encoding="UTF-8"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:patient="http://www.lifelinetransports.org/Transports/patient#"
xmlns:hospital="http://www.lifelinetransports.org/Symptoms/">
	<rdf:Description rdf:about="http://www.lifelinetransports.org/Transports/patient#info">
		<patient:fullName>John Doe</patient:fullName>
		<patient:Symptoms> Chest Pain, Bradycardia, Chest Discomfort
</patient:Symptoms>
		<patient:transportMethod>Ambulance</patient:transportMethod>
	</rdf:Description>
	<rdf:Description rdf:about="http://www.lifelinetransports.org/Symptoms/">
		<patient:Symptoms> Chest Pain, Bradycardia, Chest Discomfort
</patient:Symptoms>
	</rdf:Description>
</rdf:RDF>
```


Figure 33. RDF/XML

specific medical records for the patient currently being transported. The advantage of this specific unique query is that only relevant information about the patient's problems and their transport needs is received.

Our research produces context aware results. A query for a patient suffering from, e.g., an acute urinary tract infection will produce medical record results that include previous treatment for bladder cancer. A SPARQL query using RDF is able to produce these types of linked results.

When information is located these files are brought together based on a unique ID and can be stripped of all redundancies by comparing results to those results already harvested through the TRS constructor. This stripped set of documents are then brought together as a single XML file with multiple URIs to each bit of data contained in the multiple documents. This provides a single time use document for providing relevant information during patient transport. Using data from this document, plus new data generated during the transport another patient document is created based on the TRS Profiles from the IHE. This document details the specific transport and can be used in similar fashion by the receiving medical institution as the above process describes.

```
PREFIX patient: <
http://www.lifelinetransports.org/Transports/patient#>
PREFIX symptom:
<http://www.lifelinetransports.org/Symptoms>
     SELECT ?Disease
     WHERE { ?who patient:fullName ?givenName . ?who
patient:symtpom ?Symptoms.
http://lifelinetransports.org/Symptoms
        }
```

Figure 34. SPARQL Query

6.2.4 XML Parsing

Using LINQ (Language-Integrated Query) for XML we can parse the XML file using the XElement method shown in Figure 35.

We load the retrieved CDA XML documents into the XElement method using the path variable. We then determine any namespaces associated with the XML document, so that we can strip them from the appropriate section headings while searching terms in the standardized set. Next, since our semantic search returns relevant key words, we have to place these multiple words into a string array. We then search through the section headings of the CDA document for those words using the "*foreach*" loop. This loop queries each section for the relevant keyword information. Once located, the block is extracted to the console writer which in turn begins to build a new XML tree with that block. It is possible that the block will contain more than one word, though it doesn't match. In this case, it truncates everything before and after that word and only imports the single word plus its encapsulated XML heading. Searching multiple documents will yield multiple blocks with the same section title, if this is the case, it will then search the newly generated XML document

```
XElement xml = XElement.Load(path);
XNamespace ns = xml.GetDefaultNamespace();
foreach (string str in lstOfStrings)
{
   IEnumerable<XElement> symptoms =
   from item in xml.Descendants(ns + "section")
   where item.Element(ns + "title").Value.Contains(DropDownList1.Text)
   where item.Element(ns + "text").Value.Contains(str)
   select item;
         foreach (var complaints in symptoms)
             {
       _writer = new
       TextBoxStreamWriter(txtConsole);
       Console.SetOut(_writer);
       Console.WriteLine(complaints);
             }
           Console.ReadLine();

       }
```

Figure 35. XML Parsing

for the same section title and if there is a match it will add the word to that section, therefore removing redundancies.

When searching for relevant information, relevancy is based on a few factors. Relevancy can be based on the most recent visit (DATE) or by type of document (TYPE). A person who has been seen recently multiple times for the same problem at the local hospital and is now requesting a 911 ambulance might require a search by DATE to see what has been going on recently. An interfacility transport for a patient who needs a higher level of Oncology care might require a search by TYPE to see their entire Oncology history. In addition there is no hard fast rule and a search of both kinds might be required.

Our method searches for the parts of these documents that are relevant to the transport and does not require the entire document. This information is specified by the specific URIs shown in Figure 32. These records can be updated with each visit [69]. One example would be when a patient is scheduled for transfer to a major medical institution for treatment after reaching some Hospital C. Utilizing a semantic search, we would be able to query all the information that is relevant to this patient based on the current chief complaint. The relationship can be defined through ICD-10-CM codes or SNOMED as two examples. ICD-10-CM codes use a hierarchical structure to define conditions and traverse this structure so as to provide links to additional diagnoses for each patient. A person who has an ICD-10-CM code of M81.0: “Age –related osteoporosis without current pathological fractures” under the Diseases of the Musculoskeletal System and Connective Tissue search item may link to another category, M19.9: “Secondary Osteoarthritis, Unspecified Site”. These code based systems create a symbiotic environment for semantic queries. The TRS profiles provide similar coding systems for patients and are a source for additional linked information on patients who are transported. Semantic queries can also be used in the public health domain to find out about certain common epidemics, either locally or globally based on queries across the healthcare domain. These queries will link common medical conditions and histories leading up to the current epidemic and will find common links.

Our queries are serialized to make a single patient specific XML file that can be updated and stored in the transport RDF store. This single XML file is retrievable by the receiving institution for similar actions.

6.3 Diagnosis Support system

An ontological search can help users who are not familiar with the current domain find relevant information. Given a search for "Deafness", the results themselves may provide more detailed scientific terms to narrow the search and make it more specific to the disease process, perhaps a search on "Cochlear Implants" [37]. Our search may return diseases based on symptoms, but we can then use the related symptoms with each returned disease to see if those symptoms as a whole represent a high confidence level towards our main disease process based on the current symptoms. This can rule out semantically related, but medically insignificant differential diagnosis from the current issue and provide decision support for appropriate treatment.

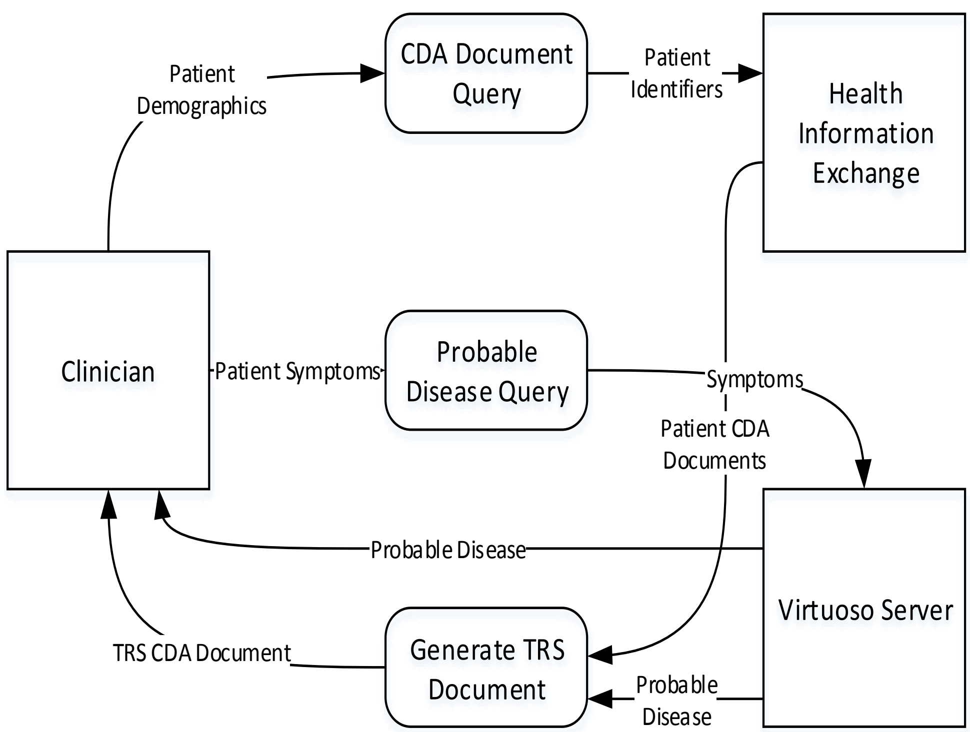

Figure 36. Module Diagram

6.3.1 911 Scenario

Patient Smith experiences severe chest pain, a sure sign he is having a heart attack. Smith is able to make it to the phone to dial 911 and report his emergency, but soon after collapses to the ground unconscious. Patient Smith has never contacted 911 before and the fire department is not familiar with him or his medical history. Upon arrival paramedics are able to find identifying demographics and log into the local health information exchange where these demographics are matched up with the patient ID using the master patient index, a list of previously used IDs associated with his demographics as shown in Figure 36 under the *CDA Document Query* module. Now able to access his previous health record's CDA documents, the paramedics input his symptoms and search possible diseases both in his past medical history and as a new diagnosis as seen in the Figure 36 *Probable Disease Query* module. This completed record is created by the Figure 36 *Generate TRS Document* module and becomes a new CDA document based on our Transport Record Summary (TRS) profile [68] and will continue to guide treatment for this unconscious patient who otherwise would have presented as a mystery to the paramedics.

A similar study on ontological queries in Electronic Health Records in the Massachusetts General Hospital was performed in 2011 [13]. This study sought to search EHR using ontological methods for relevant past medical history in order to avoid excessive radiology studies. The results showed that quick results provided physicians with salient data that could aid in their decision about radiology imaging as part of their work up [70]. The study

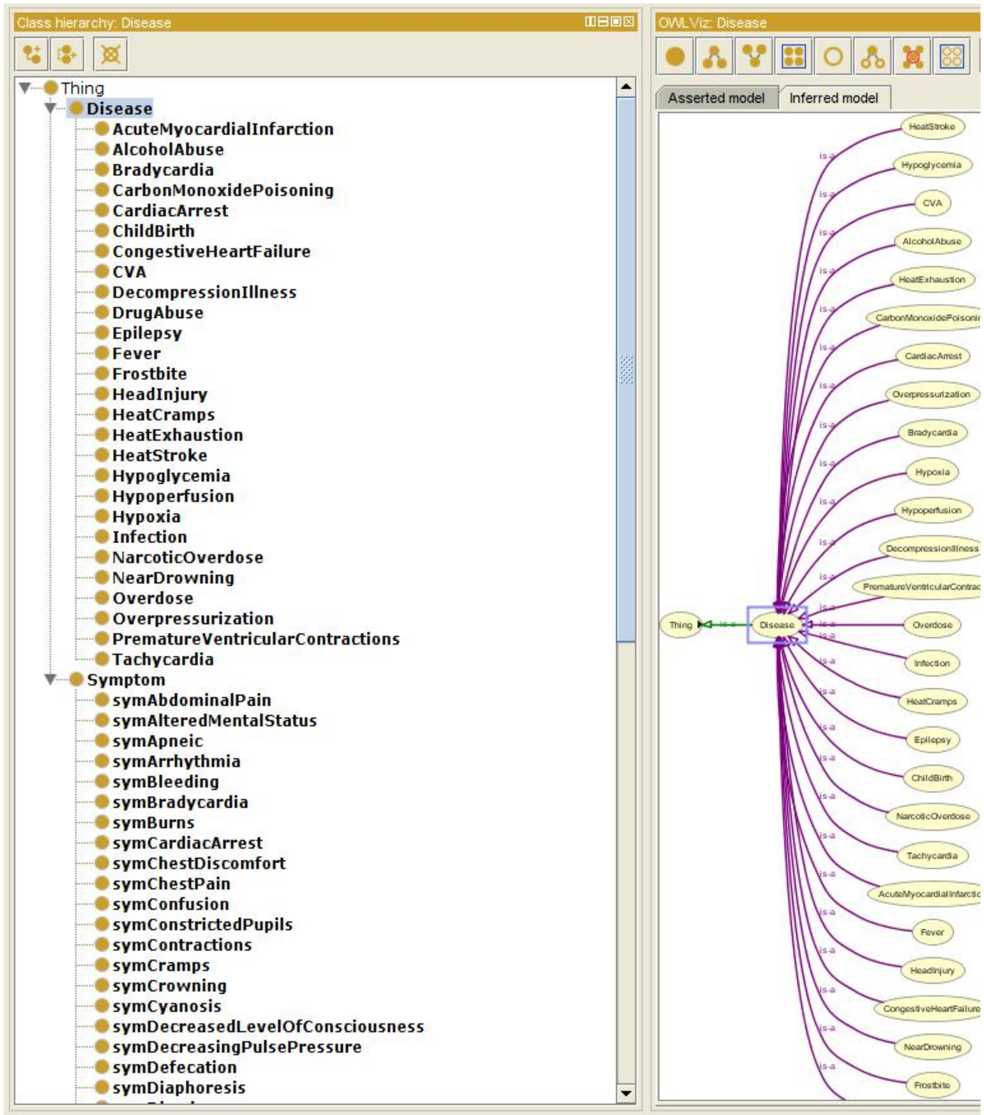

Figure 37. Protégé Disease and Symptoms Classes

indicates similar results to our search across EHRs in the emergency medical services field, in that it is limited by the available information at the time of the query and must ultimately be validated by a clinician. It was used as a tool in the decisions support process, but it was limited to providing a read only resource. Our method takes the results and creates a new CDA document based on our previous TRS profile and incorporates suggested differential diagnoses to the list to guide the provider through their treatment. Currently the only way to view CDA documents is to select individual documents, sorted by type, and view them one at a time. Our approach streamlines this process for the transport environment where time is a very limited resource; however, our methodology can be applied to other areas of healthcare where viewing a single medical document can prove advantageous. This could be in the emergency department setting or as an anesthesia report during preoperative surgery procedures.

6.3.2 Maryland Medical Protocol Ontology

We used Protégé to model our medical ontology based on the 2013 Maryland Medical Protocols for Emergency Medical Services Providers [71].

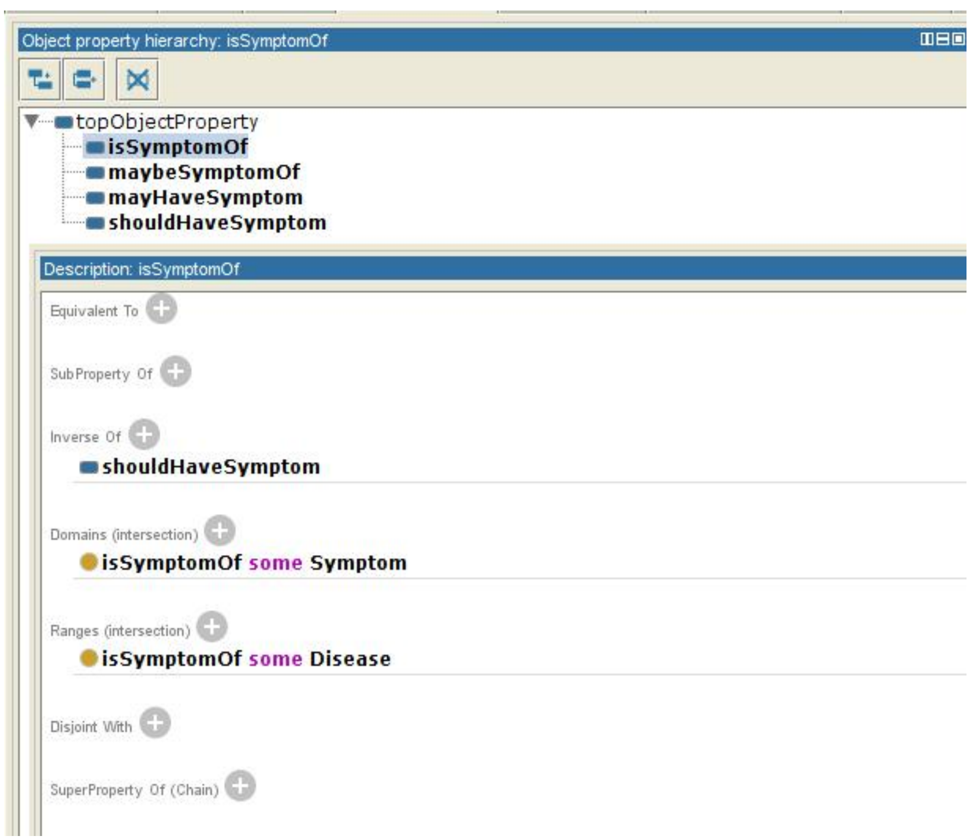

Figure 38. Protégé Object Property

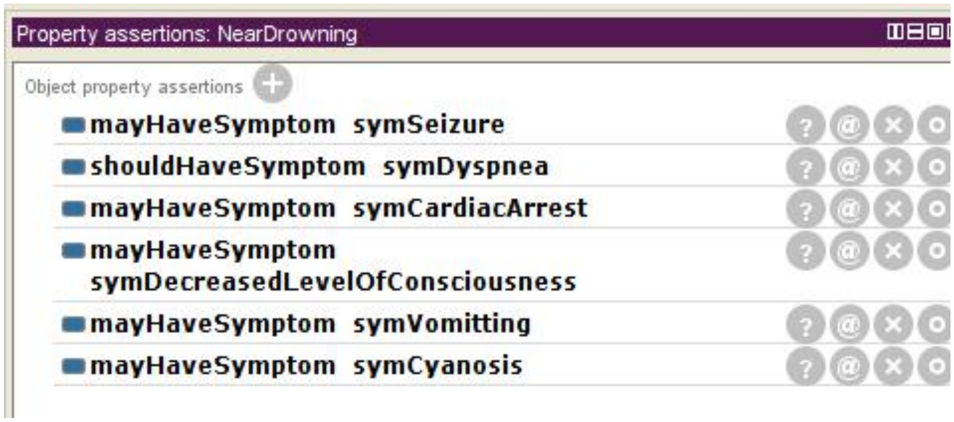

Figure 39. Protégé Assertions for *NearDrowning*

First we created classes based on Diseases and Symptoms as seen in Figure 37. Each disease and symptom class contains individuals that reference medical processes in the protocols. The protocols are broken into treatment guidelines for a variety of acute illnesses. Each section in the protocols contains a description of the disease process and the possible associated symptoms with the most prevalent symptoms at the top of the list.

Based on the information provided in the protocols we created object properties that would associate symptoms with disease and vice versa. For example, the property *isSymptomOf* in Figure 38 has an inverse relationship with *shouldHaveSymptom* and the domain is some named symptom in our list, the range is the diseases the symptom would describe.

We then defined each object property with the associated symptoms and diseases. This would create the semantic relationship among classes and object properties. The assertions for the symptoms of a *NearDrowning* appear in Figure 39.

6.3.3 Patient Symptom SPARQL Query

Our disease and symptom ontology was created in RDF by Using Protégé [72]. Protégé is a software product that allows one to build an ontology using classes and keywords and then define the relationships between those keywords and the classes through a variety of operands that describe how they are joined or disjoined. We used Openlink's Virtuoso [73] to query the RDF file that we have created. Virtuoso is a server that hosts an ontology file and supports SPARQL queries. When defining a set of queries, a prefix for the semantic query needs to be set. This prefix defines the ontology file we will be using for the specific query. We used the prefix "semed" and declared it in the following example.

```
PREFIX semed:
http://www.semanticweb.org/semedicine/ontologies/201
3/5/semedicine-ontology-7#
```

Once set, we then used a select statement to find out which disease a certain symptom is a subset of. In this example we search using the symptom Dyspnea, or shortness of breath:

```
SELECT ?d
WHERE { semed:symDyspnea semed:isSymptomOf  ?d . }
```

This returns a list of results:

```
(?d =
<http://www.semanticweb.org/semedicine/ontologies/20
13/5/semedicine-ontology-7#CarbonMonoxidePoisoning>
)
(?d =
<http://www.semanticweb.org/semedicine/ontologies/20
13/5/semedicine-ontology-7#NearDrowning> )
(?d =
<http://www.semanticweb.org/semedicine/ontologies/20
13/5/semedicine-ontology-7#Overpressurization> )
```

The returned results describe diseases based on the provided symptom. The *?d* describes the matching disease. The URI refers to the prefix *semed* (already defined) and the information following the # sign lists the actual disease. So the above results refer to three diseases: Carbon Monoxide Poisoning, Near Drowning and Over-pressurization. We can also search the opposite information based on the results. We can search which symptoms may be symptoms of the previous result set. In this example we use the first returned result *CarbonMonoxidePoisoning*:

```
SELECT ?s
WHERE { ?s semed:maybeSymptomOf
semed:CarbonMonoxidePoisoning . }
```

This returns a list of results:

```
( ?s =
<http://www.semanticweb.org/semedicine/ontologies/20
13/5/semedicine-ontology-7#symVomitting> )
( ?s =
<http://www.semanticweb.org/semedicine/ontologies/20
13/5/semedicine-ontology-7#symUnconscious> )
( ?s =
<http://www.semanticweb.org/semedicine/ontologies/20
13/5/semedicine-ontology-7#symSeizure> )

( ?s =
<http://www.semanticweb.org/semedicine/ontologies/20
13/5/semedicine-ontology-7#symBurns> )
```

The returned result set here is similar in format to the previous result set, except the "*?s*" refers to the symptoms and the actual symptom appears after the # symbol. The *sym* before the symptom identifies it as a symptom and so it is stripped from the result set to give us the following above returned

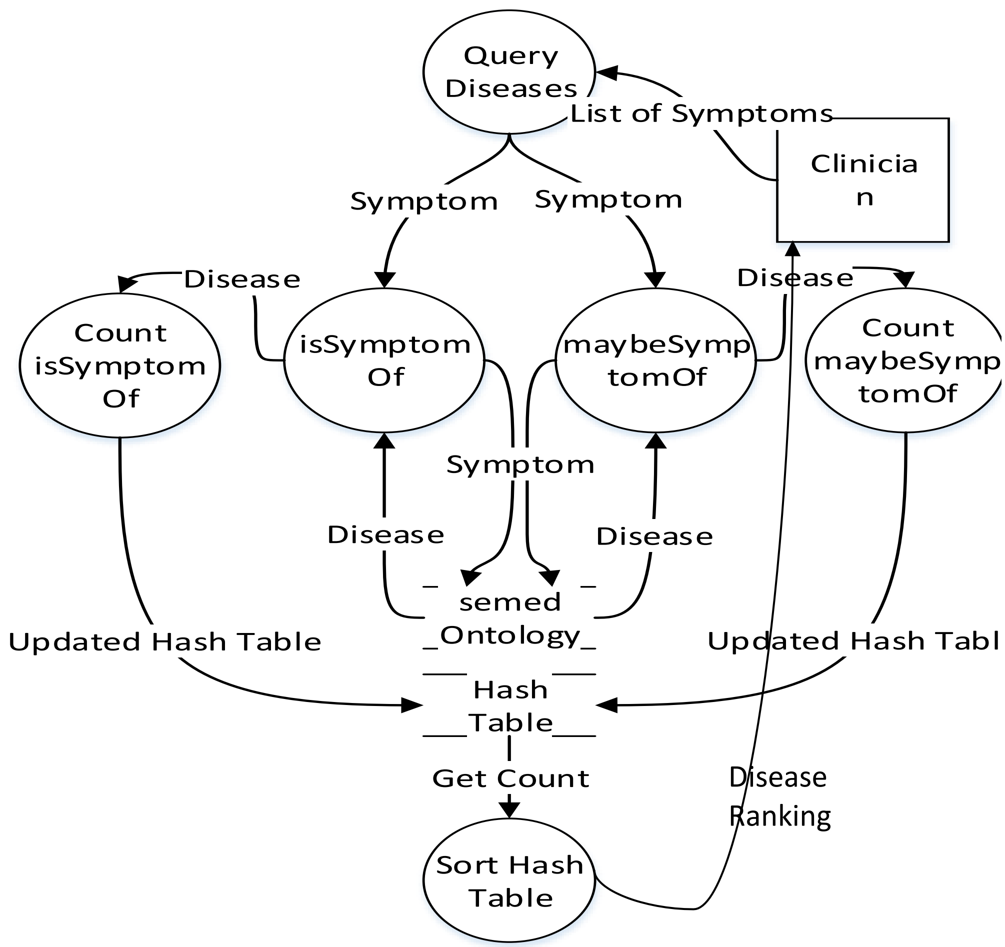

Figure 40. Probable Disease Extraction

symptoms: Vomiting, Unconscious, Seizure and Burns. We continue these searches through the remaining original result set including *NearDrowning* and *Overpressurization*.

6.3.4 Probable Disease Algorithm

With a valid ontology in place, we can then include its function within the TRS consolidator. Figure 40 shows the software architecture diagram for probable disease extraction. Using a list of symptoms provided by the clinician, the system queries the ontology for probable diseases. Lists of diseases that must have the symptom are listed with an attribute "isSymptomOf" and those that may or may not have the symptom are listed as "maybeSymptomOf".

Lines 1-11 show the Probable disease class and the output table in Figure 41.

In lines 12-14 of Figure 41, for each symptom with a corresponding disease that is returned, the counter in the "hash table" of diseases is incremented by one for the specific disease. Thus searching for probable diseases based on the confidence level counter associated with each symptom and corresponding disease. Using a hash table allows for quick search each time it is to be incremented, vs. an array which requires the entire array to be

```
1 public class Probable_disease {
2      string disease_name;
3      int shouldHaveSymptom_count;
4      int mayHaveSymptom_count;
5      Probable_disease( string t, int a,
       int b) {
6             disease_name = t;
7             shouldHaveSymptom_count = a;
8             mayHaveSymptom_count = b;
9      }
10     string disease_list (){
11      return ( disease_name + ":" +
        shouldHaveSymptom_count + "major
        matches" + "and" +
        mayHaveSymptom_count + "minor
        matches") }}

12   Foreach (string disease_name in
      hashtable Temp_PDS) {
13    If (Search_hash_table(disease_name)){
14       shouldHaveSymptom_count =
         shouldHaveSymptom_count + 1;
       }
  // if the disease doesn't exist in   table
15    Else {
16      add_hash_table(disease_name);
17      shouldHaveSympton_count =
        shouldHaveSymptom_count + 1;
       }
       }
```

Figure 41. Pseudo Code Disease Algorithm

search each time as opposed to jumping to the specific associated disease in the hash table. Using iterative steps we can count the number of should have symptoms and may have symptoms and add +1 to the counter variable seen in line 14 of Figure 41.

In line 15, if the disease does not exist in the count, add the name to the table of probable diseases seen in line 16 and set the count to +1 in line 17.

The deployment diagram in Figure 42 shows the Argus Server which provides a cloud based application to run the probable disease algorithm from any mobile device. This application user guide is found in Appendix B: Argus Medical Record Transport System User Manual. A clinician can connect to the Argus server which in turn facilitates communication between the HIE, our developed ontology in the form of a RDF triple store on the virtuoso server and

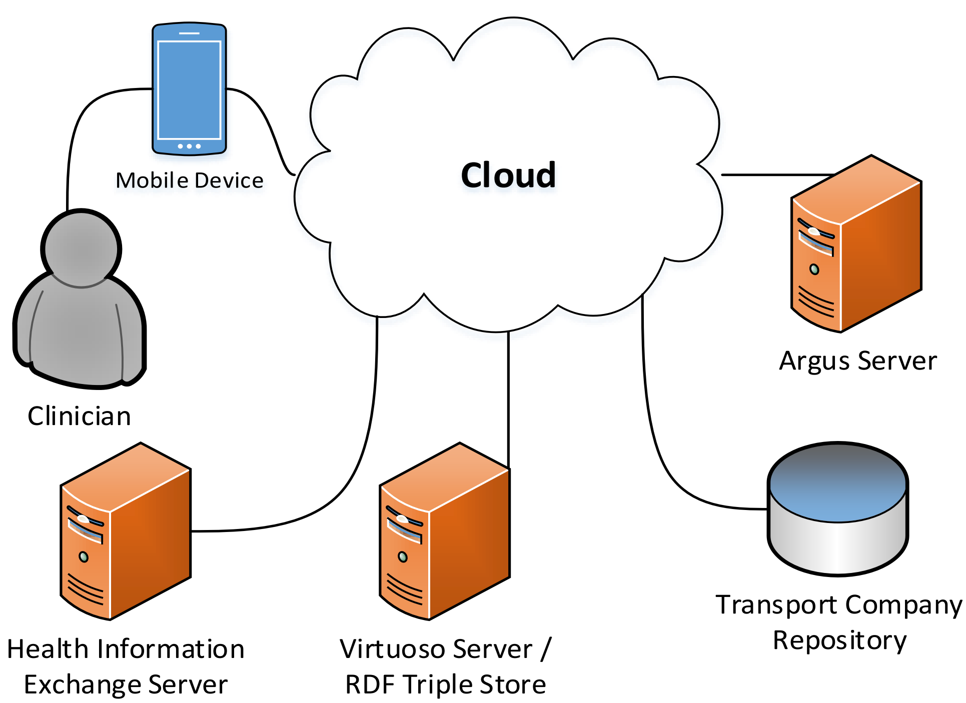

Figure 42. Deployment Diagram

the local repository of the transport company where the TRS document is stored for future HIE access.

Finally we can clinically rule in or rule out a probable disease by sorting the hash table with those diseases that have “isSymptomOf” count of at least 1 and “maybeSymptomOf” count of > 2 that was created in line 11. The limits of 1 and 2 respectively above are based on the correlation of minor symptoms to major symptoms of a specific disease. That is to say if a person experiences a symptom listed as a major symptom, the probability that the person is suffering from that specific disease is high. In addition if a person exhibits symptoms that are considered minor symptoms of the same disease, this adds to the probability of being diagnosed with that specific disease. Since minor symptoms can also be symptoms of other diseases, thus we must include a minimum limit value to the number of minor symptoms that must be included to consider the probable disease valid. An example of such symptoms associated with a disease would be a person experiencing chest pain, ST elevation in their EKG, nausea and dizziness. Chest pain and ST elevation are major symptoms associated with a Myocardial Infarction (Heart Attack). In addition to these major symptoms, nausea and dizziness can also be present; however nausea and dizziness can also be present when a person suffers from carbon monoxide poisoning, as well as other diseases. However, since chest pain and ST elevation are NOT major symptoms of carbon monoxide poisoning, it will be ruled out. We will then count the number of major and minor symptoms and discover that for the heart attack there are 2 major and 2

Myocardial Infarction: 2 major matches and 2 minor matches
CarbonMonoxidePoisoning: 0 major matches and 2 minor matches
Overpressurization: 0 major matches and 2 minor matches

Figure 43. Confidence Results before Filter Criteria

minor symptoms present. We would initially still list carbon monoxide poisoning in the hash table and it would have 0 major symptoms and 2 minor symptoms. Thus when we filter against our rule in criteria, carbon monoxide poisoning would be ruled out and only a heart attack would remain. Validation of the above ranking criteria will ultimately be performed by a licensed clinician or consensus of such. Those that will be discarded will have values less than the rule specifies. The specific rule is based on a confidence level of all inclusive symptoms available and a set of results is seen in Figure 43.

Chapter 7
Conclusion

This research aims to provide a method for healthcare practitioners in the transport medicine environment to improve patient care provided both during 911 transports and while transporting a patient between medical institutions. First, we created a standard for sharing the data collected during the transport. Second, we developed our process within the context of various enterprise architecture frameworks. Third, we built software that would query patient records available in the health information exchange and consolidate that information into a single document. Finally, we added intelligent queries through an ontological approach of searching the available patient records based on the current symptoms of that patient they were transporting. We also provided diagnosis support system based on those symptoms to provide possible medical conditions the patient was experiencing. We compiled this information into a single XML document for both the transport clinician and the health information exchange for future use.

The Transport Record Summary Profiles were developed to provide a standardized method for tracking data throughout all types of patient transports. It then breaks down the unique characteristics of both 911 and interfacility transports. This information is stored as an HL7 CDA XML document that can be shared between health information exchanges.

In order to populate the TRS profiles, we had to implement an enterprise architecture strategy that would levy the goals of all stakeholders and business processes so that we could provide meaningful information to those involved. This is where the interoperability layer integrates what the business will need, not what it currently has. The interoperability layer provides a gap analysis between these two endpoints. These considerations provided the best result for the TRS profile.

After our profile was published we began the process of software development to prove our research. The TRS constructor is the set of specific algorithms that consolidate all the patients existing electronic health records into a single document that highlights on the most relevant information based on the patients current symptoms and chief complaint for this transport. It does not delete any of the previous medical history, but rather provide a condensed format that can be readily used during emergency transports, which by nature are time restricted. The TRS constructor identifies the current patient through the Patient Query Manager, each CDA document is decomposed by the CDA XML processor, the extracted sections are filtered by the CDA Document Optimizer to remove redundancies and then finally each relevant section is consolidated into the single XML file by the Transport CDA Consolidator

We proposed an ontological approach to treating patients in an emergency situation. This helps emergency medical services providers assess a patient according to their current symptoms. The proposed approach searches all available electronic health records in the health information exchange using the symptoms as a seed for an ontological query. We developed a medical ontology based on the Maryland medical protocol and it associates diseases with symptoms and assigns a confidence level to each disease based on the number of present associated symptoms. Based on the chief complaints from a patient, the proposed algorithm queries the ontology and returns a list of probable symptoms. Using this list we associated each disease with each returned symptom and if a symptom returned multiple times associated with the same disease we include this disease in our list of probable diseases. In addition, the list of symptoms and related diseases are used to search the EHRs and return a single document with all relevant past medical history based on the current chief complaint and set of symptoms.

Though this research began four years ago, to date there is still no complete published solution to our research problem. Our TRS profile is the first of its kind to have been published and vendors in the healthcare industry are working to implement a solutions based on the profile. Our associated proof of concept software demonstrates the abilities documented within this body of research. The IT industry has become more focused on mobile devices and the healthcare industry is no exception. Our cloud based solution has been designed with the mobile environment in mind and our developed TRS standard provides a consistent structure that can be implemented across multiple domains.

Appendices

7.1 Appendix A: IHE Transport Record Summary Profile

Integrating the Healthcare Enterprise

IHE Patient Care Coordination (PCC)

Technical Framework Supplement

Transport Record Summary Profiles

(Includes ETS and ITS)

Date: September 9, 2011

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Foreword

This is a supplement to the IHE Patient Care Coordination Technical Framework 6.0. Each supplement undergoes a process of public comment and trial implementation before being incorporated into the volumes of the Technical Frameworks.

This supplement is submitted for Public Comment between June 3, 2011 and July 3, 2011. Comments are invited and may be submitted at http://www.ihe.net/pcc/pcccomments.cfm. In order to be considered in development of the Trial Implementation version of the supplement comments must be received by July 3, 2011.

This supplement describes changes to the existing technical framework documents and where indicated amends text by addition (**bold underline**) or removal (~~**bold strikethrough**~~), as well as addition of large new sections introduced by editor's instructions to "add new text" or similar, which for readability are not bolded or underlined.

"Boxed" instructions like the sample below indicate to the Volume Editor how to integrate the relevant section(s) into the relevant Technical Framework volume:

General information about IHE can be found at: www.ihe.net

Information about the IHE Patient Care Coordination domain can be found at: http://www.ihe.net/Domains/index.cfm

Information about the structure of IHE Technical Frameworks and Supplements can be found at: http://www.ihe.net/About/process.cfm and http://www.ihe.net/profiles/index.cfm

The current version of the IHE Technical Framework can be found at: http://www.ihe.net/Technical_Framework/index.cfm

TABLE OF CONTENTS

Introduction

The Transport Record Summary Profile contains the specific information that will be shared during both pre-hospital (911) and interfacility medical transports. Each environment is unique with its own set of challenges and this profile aims to alleviate these issues. It incorporates with the receiving facility care setting to provide near real-time patient information.

This supplement is written for Trial Implementation. It is written as changes to the documents listed below. The reader should have already read and understood these documents:

1. PCC Technical Framework Volume 1, Revision 6.0
2. PCC Technical Framework Volume 2, Revision 6.0

This supplement also references other documents[1]. The reader should have already read and understood these documents:

1. IT Infrastructure Technical Framework Volume 1, Revision 7.0
2. IT Infrastructure Technical Framework Volume 2, Revision 7.0
3. IT Infrastructure Technical Framework Volume 3, Revision 7.0
4. The Patient Identifier Cross-Reference (PIX) and Patient Demographic Query (PDQ) HL7 v3 Supplement to the IT Infrastructure Technical Framework.
5. HL7 and other standards documents referenced in Volume 1 and Volume 2

Open Issues and Questions

1. *Mandatory Inclusion Flag, Conformance and Cardinality in content module tables 6.3.1.A.4-1, 6.3.1.B.4-1, 6.3.1.C.4-1 is a new convention under discussion and may change based on further feedback.*
2. *New LOINC IDs needed.*
3. *Is the table MOST UP TO DATE WITH RECENT LOINC, DEEDS, NEMSIS changes?*

Closed Issues

1. *Do we combine profiles into one that accomplishes the task of ETC, EDR and this profile?*
2. *Proper use cases?*

[1] The first four documents can be located on the IHE Website at http://www.ihe.net/Technical_Framework/index.cfm#IT. The remaining documents can be obtained from their respective publishers.

3. *Which fields are R, R2 or O?*
4. *Profile Name?*
5. *NEMSIS Version 3*
6. *What are other countries doing to support pre-hospital HIT systems?*
7. *Should the EMS part of the sequence diagram be greyed out still?*
8. *Are advance directives R2 or R?*
9. *What are the Physician Update Service Options?*
10. *What are the PCR Reconciliation Service Options?*
11. *What are the clinical data consumer options?*
12. *Where is the appropriate place to list master headings and sub headings to cover all types of transfers (EDES, EDR, ETC, ENS, etc.)*
13. *The above questions are null as the profile is taking a different approach.*

Volume 1 – Profiles

1.5 Copyright Permissions

2.4 Dependencies of the PCC Integration Profiles

None

2.5 History of Annual Changes

In the 2011-2012 cycle of the Patient Care Coordination Initiative, the following content profile was added as a supplement to the technical framework.

- Deprecated the EMS Transfer of Care (ETC) Profile.
- Added the Transport Record Summary Profile that supports the exchange of clinically relevant data between all transport medicine providers and healthcare facilities.

X EMS Transport Summary

X.1 Purpose and Scope

The goal of this profile is to detail how information is shared during all aspects of patient transport. Whenever a patient is moved between facilities and care services their information about this specific event needs to travel with them. The ability to share this information with the transporters, regardless of transport time, is essential to complete patient care.

We are focused on only those events that involve a transport team, which for this profile is defined as any team of license or certified care providers that create content for the EMR. This team may be part of a fixed wing, helicopter or ambulance transport

We are not focused on multiple events associated with long term patient care, but rather each incident that requires a specific number of transports between health care settings.

X.2 Process Flow

X.2.1 EMS Transport

The process flow for EMS Transfers of care is shown in Figure X.2.2-1 below. Upon determination of the patient identity, the prehospital provider consumes data previously gathered in other IHE PCC Profiles (e.g., through PHR or HIE system). The prehospital provider creates new data relevant to the care provided. This combined data of the prehospital emergency care provided is then shared with the emergency department content consumer (EDIS). The shaded actors are defined elsewhere in IHE PCC profiles. For details on these actors, see section X.5.6 Grouping with Other PCC Content Profiles.

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.

X.2.3 Diagrams

EMS Transport

A transport clinician first must request authorization for access to EMR or appropriate spokesperson. The clinician can then locate the EMR and update it with current clinical information during the transport. The EMR is can then be shared with the local EDIS.

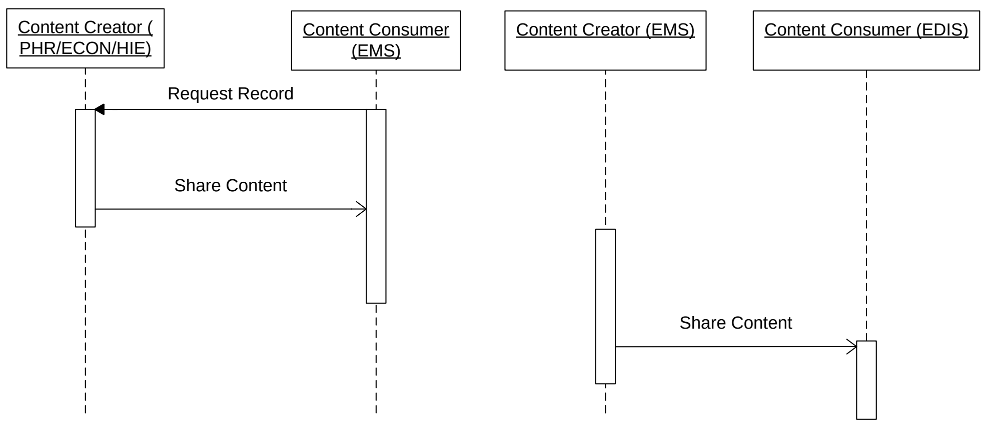


Figure X.2.3-1. EMS Transport Sequence Diagram in Transport Record Summary Profile

X.3 Actors/Transactions

Figure X.3-1 shows the actors directly involved in the Transport Record Summary Profile and the relevant transactions between them. Other actors that may be indirectly involved due to their participation in ETC, EDR, EDES, etc. are not necessarily shown. A Document Source or a Portable Media Creator may embody the Content Creator Actor. A Document Consumer, a Document Recipient or a Portable Media Importer may embody the Content Consumer Actor. The sharing or transmission of content or updates from one actor to the other is addressed by the use of appropriate IHE profiles described in the section on Content Bindings with XDS, XDM and XDR in PCC TF-2:4.1.

X.3.1.1 Content Agent

The Content Agent actor accesses clinical information in structured and non-structured form.
It provides a mechanism for a clinician to add new information to the structured and non-structured information.
It authenticates the clinician prior to storage of the additional information data (this step may be combined with other authentication steps used to finalize the record).

Figure X.3-1. ETS Actor Diagram

X.4 Options

Actor	Option
Content Consumer	View Option (1)
	Document Import Option (1)
	Section Import Option (1)
	Discrete Data Import Option (1)
Content Creator	No options defined
Reconciliation Agent	No Options Defined

Note 1: The Actor shall support at least one of these options.

X.4.1 Content Consumer Options

X.4.1.1 View Option

This option defines the processing requirements placed on Content Consumers for providing access, rendering and management of the medical document. See the View Option in PCC TF-2:3.1.1 for more details on this option.

A Content Creator Actor should provide access to a style sheet that ensures consistent rendering of the medical document content as was displayed by the Content Consumer Actor.

The Content Consumer Actor shall be able to present a view of the document using this style sheet if present.

X.4.1.2 Document Import Option

This option defines the processing requirements placed on Content Consumers for providing access, and importing the entire medical document and managing it as part of the patient record. See the Document Import Option in PCC TF-2:3.1.2 for more details on this option.

X.4.1.3 Section Import Option

This option defines the processing requirements placed on Content Consumers for providing access to, and importing the selected section of the medical document and managing them as part of the patient record. See the Section Import Option in PCC TF-2:3.1.3 for more details on this option.

X.4.1.3 Discrete Data Import Option

This option defines the processing requirements placed on Content Consumers for providing access, and importing discrete data from selected sections of the medical document and managing them as part of the patient record. See the Discrete Data Import Option in PCC TF-2:3.1.4 for more details on this option.

X.5 Groupings

This section describes the behaviors expected of the Content Creator and Content Consumer actors of this profile when grouped with actors of other IHE profiles.

X.5.1 Content Bindings with XDS, XDM and XDR

It is expected that the exchanges of this content will occur in an environment where prehospital providers and emergency care centers have a coordinated infrastructure that serves the information sharing needs of this community of care. Several mechanisms are supported by IHE profiles:

A registry/repository-based infrastructure is defined by the IHE Cross Enterprise Document Sharing (XDS) and other IHE Integration Profiles such as patient identification (PIX & PDQ) and notification of availability of documents (NAV).

A media-based infrastructure is defined by the IHE Cross Enterprise Document Media Interchange (XDM) profile.

A reliable messaging-based infrastructure is defined by the IHE Cross Enterprise Document Reliable Interchange (XDR) profile.

All of these infrastructures support Security and privacy through the use of the Consistent Time (CT) and Audit Trail and Node Authentication (ATNA) profiles.

For more details on these profiles, see the IHE IT Infrastructure Technical Framework[2]. Content profiles may impose additional requirements on the transactions used when grouped with actors from other IHE Profiles.

[2] See http://www.ihe.net/Technical_Framework/index.cfm#IT

X.5.2 Cross Enterprise Document Sharing, Media Interchange and Reliable Messages

Actors from the ITI XDS, XDM and XDR profiles most often embody the Content Creator and Content Consumer sharing function of this profile. A Content Creator or Content Consumer may be grouped with appropriate actors from the XDS, XDM or XDR profiles, and the metadata sent in the document sharing or interchange messages has specific relationships to the content of the clinical document described in the content profile.

X.5.3 Audit Trail and Node Authentication (ATNA)

When the Content Creator or Content Consumer actor of this profile is grouped with the Secure Node or Secure Application actor of the ATNA profile, the content creator actor shall generate appropriate audit record events for each of the following trigger events:

Trigger Event	Description
Actor-start-stop	Start up and shut-down of the content creator or content consumer actor.
Patient-Record-Event	Creation, access, modification[3] or deletion of the content described within this profile.
Node-Authentication-Failure	Secure node authentication failure is detected.

The above list is a minimum set that must be demonstrated by all actors of this profile when grouped with the secure node or secure application actor. Additional audit records shall also be generated depending upon the actions available the product implementing the secure node or secure application actor.

X.5.4 Notification of Document Availability (NAV)

A Document Source should provide the capability to issue a Send Notification Transaction per the ITI Notification of Document Availability (NAV) Integration Profile in order to notify one or more Document Consumer(s) of the availability of one or more documents for retrieval. One of the Acknowledgement Request options may be used to request from a Document Consumer that an acknowledgement should be returned when it has received and processed the notification. A Document Consumer should provide the capability to receive a Receive Notification Transaction per the NAV Integration Profile in order to be notified by Document Sources of the availability of one or more documents for retrieval. The Send Acknowledgement option may be used to issue a Send Acknowledgement to a Document Source that the notification was received and processed.

---

[3] Clinical documents are not normally modified after being finalized. However, prior to that event one or more parties may author the content in stages. Each subsequent stage should be treated as a modification of the previous stage.

X.5.5 Document Digital Signature (DSG)

When a Content Creator Actor needs to digitally sign a document in a submission set, it may support the Digital Signature (DSG) Content Profile as a Document Source. When a Content Consumer Actor needs to verify a Digital Signature, it may retrieve the digital signature document and may perform the verification against the signed document content.

X.5.6 Grouping with Other PCC Content Profiles

When the Content Creator of this profile is grouped with a Content Consumers of other profiles found in the IHE PCC Technical Framework, the following key information available in documents specified in these profiles must be able to be transferred from consumer to the creator for incorporation into the exchange.

Profiles **Entries**	**XDS-MS** (Cross Enterprise Document Sharing of Medical Summaries)	**XPHR** (Exchange of Personal Health Record)	**EDR** (Emergency Department Referral)	**EDES** (Emergency Department Encounter Summary)
Emergency Contact Information	R	R	R	R
Problems	R	R	R	R
Medications	R	R	R	R
Allergies	R	R	R	R
Advance Directives (e.g., DNR status)	R2	R2	R	R
Pregnancy Status	R2	R2	R2	R2

R = Required, R2 = Required if data available

X.6 Security Considerations

<Description of the Profile specific security considerations. This should include the outcomes of a risk assessment. This likely will include profile groupings, and residual risks that need to be assigned to the product design, system administration, or policy.>

X.7 Content Modules

Content Modules describe the content of a payload found in an IHE transaction. Content profiles are transaction neutral. They do not have dependencies upon the transaction that they appear in.

The Transport content module is intended to support the exchange of information gathered during pre-hospital emergency care, interfacility care and obtained via other IHE content profiles (e.g., in the case where the EMS system is able to obtain relevant information from a PHR or other HIT system, such as an emergency contact registry (i.e., VIN# ECON, DL# ECON).

This content module incorporates other content modules already present in this Technical Framework. The names of these content modules do not always use the terminology used by emergency care providers (e.g., Review of Systems). However, the data elements found in these sections are identical in content regardless of the level of training of the care providing that information, be they a nurse, physician or other health care professional. The purpose of section classification is to identify the type of information found in it. The author that generated this information is separately identified within the content module.

Table X.7-1 describes an asbtract list of data elements that must be part of the information presented in tables X.7-2, EMS Transport Data Element Index.

Table X.7-1 Transport Data Element Index

Data Element	DEEDS	NEMSIS v3	PCC Template	PCC Template ID
Chief Complaint / Primary Diagnosis	4.06 Chief Complaint	**ESituation.04** Complaint	Chief Complaint	1.3.6.1.4.1.19376.1.5.3.1.1.13.2.1

Data Elemen t	DEEDS	NEMSIS v3	PCC Template	PCC Tem plat e ID
Medicatio ns Given	7.04 ED Medication	**EMedications.03** Medication Given	Medications Given	1.3.6.1.4.1.1937 6.1.5.3.1.3.21
Reason for Referral	**Not Available**	**EPayment.43** Ambulance Transport Reason Code	Reason for Referral	1.3.6.1.4.1.1937 6.1.5.3.1.3.1
History Present Illness	5.15 ED Clinical Finding	**ESituation.05** Duration of Chief Complaint	History Present Illness	1.3.6.1.4.1.1937 6.1.5.3.1.3.4

Data Elemen t	DEEDS	NEMSIS v3	PCC Template	PCC Tem plat e ID
History of Pregnanci es	**5.15** ED Clinical Finding	**EHistory.20** Pregnancy	History of Pregnancies	1.3.6.1.4.1.1937 6.1.5.3.1.1.5.3.4
Acuity Assessme nt	4.08 First ED	**Not Available**	Acuity Assessment	1.3.6.1.4.1.1937 6.1.5.3.1.1.13.2. 2
Active Problems	5.15 ED Clinical Finding	**EHistory.10** Medical/Surgical History	Active Problems	1.3.6.1.4.1.1937 6.1.5.3.1.3.6

Data Element	DEEDS	NEMSIS v3	PCC Template	PCC Template ID
Current Medications	5.09 Current Therapeutic Medication	**EHistory.14** Current Medications	Current Medications	1.3.6.1.4.1.19376.1.5.3.1.3.19
Allergies	5.15 ED Clinical Finding	**EHistory.08** Medication Allergies, **EHistory.09** Environmental/Food Allergies	Allergies	1.3.6.1.4.1.19376.1.5.3.1.3.13
Immunizations	**5.15** ED Clinical Finding	**EHistory.12** Immunization History	Immunizations	1.3.6.1.4.1.19376.1.5.3.1.3.23

Data Element	DEEDS	NEMSIS v3	PCC Template	PCC Template ID
Pertinent Review of Systems	5.15 ED Clinical Finding	**ESituation.09** Primary Symptom **ESituation.10** Other Associated Symptoms	Pertinent Review of Systems	1.3.6.1.4.1.1937 6.1.5.3.1.3.18
Family History	**5.15** ED Clinical Finding	**Not Available**	Family History	1.3.6.1.4.1.1937 6.1.5.3.1.3.14
Social History	**5.15** ED Clinical Finding	**EHistory.19** Alcohol / Drug Use Indicators	Social History	1.3.6.1.4.1.1937 6.1.5.3.1.3.16

Data Element	DEEDS	NEMSIS v3	PCC Template	PCC Template ID
Coded Physical Examination	5.15 ED Clinical Finding	**EExam** Assessment/ Exam **EVitals** Assessment/ Vital Signs	Coded Physical Examination (Includes Required Coded Vital Signs - 1.3.6.1.4.1.19376.1.5.3.1.1.5.3.2)	1.3.6.1.4.1.19376.1.5.3.1.1.9.15.1
Relevant Surgical Procedures / Clinical Reports (including links)	**Not Available**	**EHistory.10** Medical/Surgical History	List of Surgeries	1.3.6.1.4.1.19376.1.5.3.1.3.11
Relevant Diagnostic Test and Reports (Lab, Imaging, EKG's, etc.) including links.	**Not Available**	**ELab** Laboratory / Imaging Results	Hospital Studies Summary	1.3.6.1.4.1.19376.1.5.3.1.3.29

Data Element	DEEDS	NEMSIS v3	PCC Template	PCC Template ID
Care Plan (new meds labs, or x-rays ordered)	**Not Available**	**Not Available**	Care Plan (new meds labs, or x-rays ordered)	1.3.6.1.4.1.19376.1.5.3.1.3.31
Mode of Transport to the Emergency Department	**4.02** Mode of Transport	**EDisposition.16** EMS Transport Method **EDisposition.18** Additional Transport Mode Descriptors **ETimes.11** Patient Arrived at Destination Date/Time **ETimes.06** Unit Arrived on Scene Date/Time	Mode of Transport to the Emergency Department (Includes estimated time of arrival)	1.3.6.1.4.1.19376.1.5.3.1.1.10.3.2
Advance Directives	**Not Available**	**EHistory.05** Advance Directives	Advance Directives	1.3.6.1.4.1.19376.1.5.3.1.3.34

Data Element	DEEDS	NEMSIS v3	PCC Template	PCC Template ID
Pertinent Insurance Information	**3.01** Insurance Coverage or Other Expected Source of Payment	**EPayment.01** Primary Method of Payment	Payers	1.3.6.1.4.1.19376.1.5.3.1.1.5.3.7
Sending Facility	**Not Available**	**EScene.12** Incident Facility or Location Name	Sending Facility	1.3.6.1.4.1.19376.1.5.3.1.1.25.2.1
Receiving Facility	**8.05** Facility Receiving ED Patient	**EDisposition.01** Destination / Transferred To, Name	Receiving Facility	1.3.6.1.4.1.19376.1.5.3.1.1.25.2.2

X.7-2 EMS Transport Content Module

During a transport described in Use Case 1 that originates as a pre-hospital transport where a patient is first encountered by emergency first responders, data elements located in Table X.7-2 must be included with data elements from Table X.7-1.

Table X.7-2 EMS Transport Data Element Index

Data Elements	DEEDS	NEMSIS v3	PCC Template	PCC Template ID
Injury Incident Description	5.03 Injury Incident Description	**ESituation** Situation **EInjury** Situation/Trauma	Injury Incident Description	1.3.6.1.4.1.19376.1.5.3.1.1.19.2.1
Mass Casualty Incident	**Not Available**	**EScene.07** Mass Casualty Incident	Mass Casualty Incident	1.3.6.1.4.1.19376.1.5.3.1.1.25.2.3
Unit Response Level	**Not Available**	**EPayment.49** CMS Service Level	Unit Response Level	1.3.6.1.4.1.19376.1.5.3.1.1.25.2.4
Protocols Used	**Not Available**	**EProtocols.01** Protocols Used	Protocols Used	1.3.6.1.4.1.19376.1.5.3.1.1.25.2.5
Intravenous Fluids Administered	6.02 ED Procedure	**EMedications.04** Medications Given Route, 4205 Intravenous	Intravenous Fluids Administered	1.3.6.1.4.1.19376.1.5.3.1.1.13.2.6

Y EMS Transport Summary

X.1 Purpose and Scope

The goal of this profile is to detail how information is shared during all aspects of patient transport. Whenever a patient is moved between facilities and care services their information about this specific event needs to travel with them. The ability to share this information with the transporters, regardless of transport time, is essential to complete patient care.

We are focused on only those events that involve a transport team, which for this profile is defined as any team of license or certified care providers that create content for the EMR. This team may be part of a fixed wing, helicopter or ambulance transport

We are not focused on multiple events associated with long term patient care, but rather each incident that requires a specific number of transports between health care settings.

Y.2 Process Flow

Y.2.1 Interfacility Transport

Use Case

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.

Y.2.3 Diagram

Interfacility Transport

A transport clinician first must request authorization for access to EMR or appropriate spokesperson. The clinician can then locate the EMR and update *it with current clinical information during the transport. The EMR is updated in near real-time so that the receiving facility can access the most up to date information.*

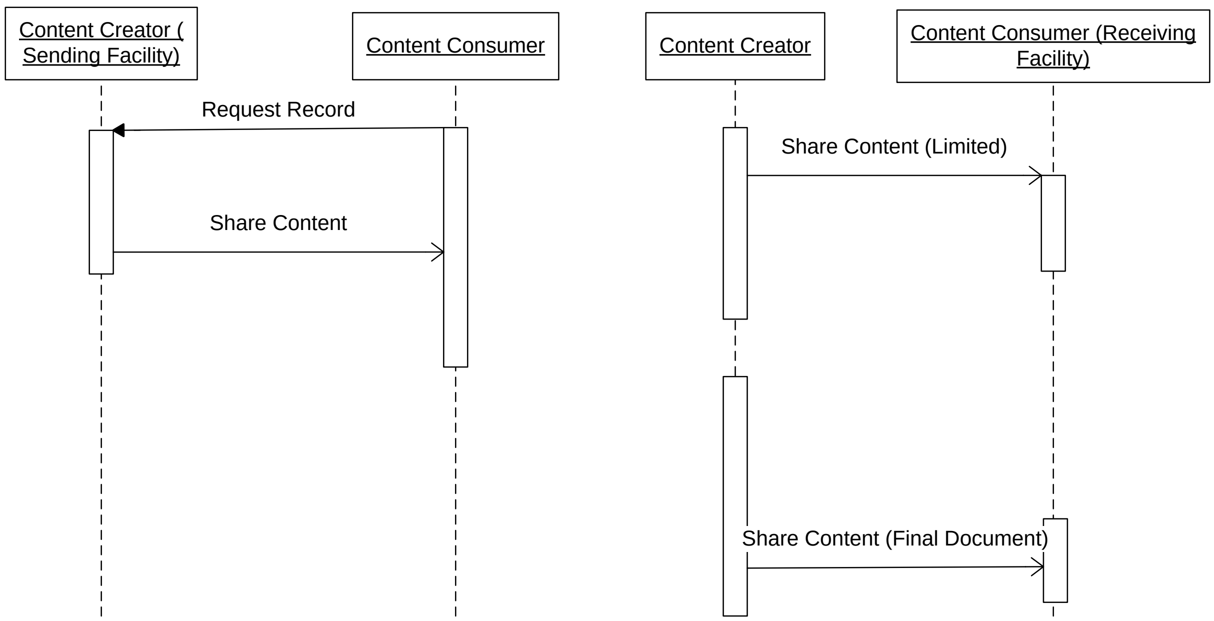


Figure X.2.3-2. Interfacility Transport Sequence Diagram in Transport Record Summary Profile

Y.3 Actors/Transactions

Figure X.3-1 shows the actors directly involved in the Transport Record Summary Profile and the relevant transactions between them. Other actors that may be indirectly involved due to their participation in ETC, EDR, EDES, etc. are not necessarily shown. A Document Source or a Portable Media Creator may embody the Content Creator Actor. A Document Consumer, a Document Recipient or a Portable Media Importer may embody the Content Consumer Actor. The sharing or transmission of content or updates from one actor to the other is addressed by the use of appropriate IHE profiles described in the section on Content Bindings with XDS, XDM and XDR in PCC TF-2:4.1.

Y.3.1.1 Content Agent

The Content Agent actor accesses clinical information in structured and non-structured form.
It provides a mechanism for a clinician to add new information to the structured and non-structured information.
It authenticates the clinician prior to storage of the additional information data (this step may be combined with other authentication steps used to finalize the record).

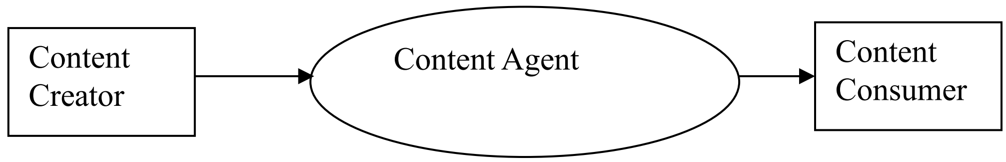


Figure X.3-1. TTP Actor Diagram

Y.4 Options

Actor	Option
Content Consumer	View Option (1)
	Document Import Option (1)
	Section Import Option (1)
	Discrete Data Import Option (1)
Content Creator	No options defined
Reconciliation Agent	No options defined

Note 1: The Actor shall support at least one of these options.

Y.4.1 Content Consumer Options

Y.4.1.1 View Option

This option defines the processing requirements placed on Content Consumers for providing access, rendering and management of the medical document. See the View Option in PCC TF-2:3.1.1 for more details on this option.

A Content Creator Actor should provide access to a style sheet that ensures consistent rendering of the medical document content as was displayed by the Content Consumer Actor.

The Content Consumer Actor shall be able to present a view of the document using this style sheet if present.

Y.4.1.2 Document Import Option

This option defines the processing requirements placed on Content Consumers for providing access, and importing the entire medical document and managing it as part of the patient record. See the Document Import Option in PCC TF-2:3.1.2 for more details on this option.

Y.4.1.3 Section Import Option

This option defines the processing requirements placed on Content Consumers for providing access to, and importing the selected section of the medical document and managing them as part of the patient record. See the Section Import Option in PCC TF-2:3.1.3 for more details on this option.

Y.4.1.3 Discrete Data Import Option

This option defines the processing requirements placed on Content Consumers for providing access, and importing discrete data from selected sections of the medical document and managing them as part of the patient record. See the Discrete Data Import Option in PCC TF-2:3.1.4 for more details on this option.

Y.5 Groupings

This section describes the behaviors expected of the Content Creator and Content Consumer actors of this profile when grouped with actors of other IHE profiles.

Y.5.1 Content Bindings with XDS, XDM and XDR

It is expected that the exchanges of this content will occur in an environment where prehospital providers and emergency care centers have a coordinated infrastructure that serves the information sharing needs of this community of care. Several mechanisms are supported by IHE profiles:

A registry/repository-based infrastructure is defined by the IHE Cross Enterprise Document Sharing (XDS) and other IHE Integration Profiles such as patient identification (PIX & PDQ) and notification of availability of documents (NAV).

A media-based infrastructure is defined by the IHE Cross Enterprise Document Media Interchange (XDM) profile.

A reliable messaging-based infrastructure is defined by the IHE Cross Enterprise Document Reliable Interchange (XDR) profile.

All of these infrastructures support Security and privacy through the use of the Consistent Time (CT) and Audit Trail and Node Authentication (ATNA) profiles.

For more details on these profiles, see the IHE IT Infrastructure Technical Framework[4]. Content profiles may impose additional requirements on the transactions used when grouped with actors from other IHE Profiles.

[4] See http://www.ihe.net/Technical_Framework/index.cfm#IT

Y.5.2 Cross Enterprise Document Sharing, Media Interchange and Reliable Messages

Actors from the ITI XDS, XDM and XDR profiles most often embody the Content Creator and Content Consumer sharing function of this profile. A Content Creator or Content Consumer may be grouped with appropriate actors from the XDS, XDM or XDR profiles, and the metadata sent in the document sharing or interchange messages has specific relationships to the content of the clinical document described in the content profile.

Y.5.3 Audit Trail and Node Authentication (ATNA)

When the Content Creator or Content Consumer actor of this profile is grouped with the Secure Node or Secure Application actor of the ATNA profile, the content creator actor shall generate appropriate audit record events for each of the following trigger events:

Trigger Event	Description
Actor-start-stop	Start up and shut-down of the content creator or content consumer actor.
Patient-Record-Event	Creation, access, modification[5] or deletion of the content described within this profile.
Node-Authentication-Failure	Secure node authentication failure is detected.

The above list is a minimum set that must be demonstrated by all actors of this profile when grouped with the secure node or secure application actor. Additional audit records shall also be generated depending upon the actions available the product implementing the secure node or secure application actor.

Y.5.4 Notification of Document Availability (NAV)

A Document Source should provide the capability to issue a Send Notification Transaction per the ITI Notification of Document Availability (NAV) Integration Profile in order to notify one or more Document Consumer(s) of the availability of one or more documents for retrieval. One of the Acknowledgement Request options may be used to request from a Document Consumer that an acknowledgement should be returned when it has received and processed the notification. A Document Consumer should provide the capability to receive a Receive Notification Transaction per the NAV Integration Profile in order to be notified by Document Sources of the availability of one or more documents for retrieval. The Send Acknowledgement option may be used to issue a Send Acknowledgement to a Document Source that the notification was received and processed.

[5] Clinical documents are not normally modified after being finalized. However, prior to that event one or more parties may author the content in stages. Each subsequent stage should be treated as a modification of the previous stage.

Y.5.5 Document Digital Signature (DSG)

When a Content Creator Actor needs to digitally sign a document in a submission set, it may support the Digital Signature (DSG) Content Profile as a Document Source. When a Content Consumer Actor needs to verify a Digital Signature, it may retrieve the digital signature document and may perform the verification against the signed document content.

Y.5.6 Grouping with Other PCC Content Profiles

When the Content Creator of this profile is grouped with a Content Consumers of other profiles found in the IHE PCC Technical Framework, the following key information available in documents specified in these profiles must be able to be transferred from consumer to the creator for incorporation into the exchange.

Profiles **Entries**	**XDS-MS** (Cross Enterprise Document Sharing of Medical Summaries)	**XPHR** (Exchange of Personal Health Record)	**EDR** (Emergency Department Referral)	**EDES** (Emergency Department Encounter Summary)
Emergency Contact Information	R	R	R	R
Problems	R	R	R	R
Medications	R	R	R	R
Allergies	R	R	R	R
Advance Directives (e.g., DNR status)	R2	R2	R	R
Pregnancy Status	R2	R2	R2	R2

R = Required, R2 = Required if data available

Y.6 Security Considerations

<Description of the Profile specific security considerations. This should include the outcomes of a risk assessment. This likely will include profile groupings, and residual risks that need to be assigned to the product design, system administration, or policy.>

Y.7 Content Modules

Content Modules describe the content of a payload found in an IHE transaction. Content profiles are transaction neutral. They do not have dependencies upon the transaction that they appear in.

The Transport content module is intended to support the exchange of information gathered during pre-hospital emergency care, interfacility care and obtained via other IHE content profiles (e.g., in the case where the EMS system is able to obtain relevant information from a PHR or other HIT system, such as an emergency contact registry (i.e., VIN# ECON, DL# ECON).

This content module incorporates other content modules already present in this Technical Framework. The names of these content modules do not always use the terminology used by emergency care providers (e.g., Review of Systems). However, the data elements found in these sections are identical in content regardless of the level of training of the care providing that information, be they a nurse, physician or other health care professional. The purpose of section classification is to identify the type of information found in it. The author that generated this information is separately identified within the content module.

Table Y.7-1 describes an asbtract list of data elements that must be part of the information presented in table Y.7-2, Interfacility Transport Data Element Index.

Table Y.7-2 Transport Data Element Index

Data Element	DEEDS	NEMSIS v3	PCC Template	PCC Template ID
Chief Complaint / Primary Diagnosis	4.06 Chief Complaint	**ESituation.04** Complaint	Chief Complaint	1.3.6.1.4.1.19376.1.5.3.1.1.13.2.1
Medications Given	7.04 ED Medication	**EMedications.03** Medication Given	Medications Given	1.3.6.1.4.1.19376.1.5.3.1.3.21
Reason for Referral	**Not Available**	**EPayment.43** Ambulance Transport Reason Code	Reason for Referral	1.3.6.1.4.1.19376.1.5.3.1.3.1
History Present Illness	5.15 ED Clinical Finding	**ESituation.05** Duration of Chief Complaint	History Present Illness	1.3.6.1.4.1.19376.1.5.3.1.3.4
History of Pregnancies	**5.15** ED Clinical Finding	**EHistory.20** Pregnancy	History of Pregnancies	1.3.6.1.4.1.19376.1.5.3.1.1.5.3.4
Acuity Assessment	4.08 First ED	**Not Available**	Acuity Assessment	1.3.6.1.4.1.19376.1.5.3.1.1.13.2.2

Data Element	DEEDS	NEMSIS v3	PCC Template	PCC Template ID
Active Problems	5.15 ED Clinical Finding	**EHistory.10** Medical/Surgical History	Active Problems	1.3.6.1.4.1.19376. 1.5.3.1.3.6
Current Medications	5.09 Current Therapeutic Medication	**EHistory.14** Current Medications	Current Medications	1.3.6.1.4.1.19376. 1.5.3.1.3.19
Allergies	5.15 ED Clinical Finding	**EHistory.08** Medication Allergies, **EHistory.09** Environmental/Fo od Allergies	Allergies	1.3.6.1.4.1.19376. 1.5.3.1.3.13
Immunizations	**5.15** ED Clinical Finding	**EHistory.12** Immunization History	Immunizations	1.3.6.1.4.1.19376. 1.5.3.1.3.23
Pertinent Review of Systems	5.15 ED Clinical Finding	**ESituation.09** Primary Symptom **ESituation.10** Other Associated Symptoms	Pertinent Review of Systems	1.3.6.1.4.1.19376. 1.5.3.1.3.18
Family History	**5.15** ED Clinical Finding	**Not Available**	Family History	1.3.6.1.4.1.19376. 1.5.3.1.3.14
Social History	**5.15** ED Clinical Finding	**EHistory.19** Alcohol / Drug Use Indicators	Social History	1.3.6.1.4.1.19376. 1.5.3.1.3.16
Coded Physical Examination	5.15 ED Clinical Finding	**EExam** Assessment/ Exam **EVitals** Assessment/ Vital Signs	Coded Physical Examination (Includes Required Coded Vital Signs - 1.3.6.1.4.1.19376. 1.5.3.1.1.5.3.2)	1.3.6.1.4.1.19376. 1.5.3.1.1.9.15.1
Relevant Surgical Procedures / Clinical Reports (including links)	**Not Available**	**EHistory.10** Medical/Surgical History	List of Surgeries	1.3.6.1.4.1.19376. 1.5.3.1.3.11
Relevant Diagnostic Test and Reports (Lab, Imaging, EKG's, etc.) including links.	**Not Available**	**ELab** Laboratory / Imaging Results	Hospital Studies Summary	1.3.6.1.4.1.19376. 1.5.3.1.3.29

Data Element	DEEDS	NEMSIS v3	PCC Template	PCC Template ID
Care Plan (new meds labs, or x-rays ordered)	**Not Available**	**Not Available**	Care Plan (new meds labs, or x-rays ordered)	1.3.6.1.4.1.19376.1.5.3.1.3.31
Mode of Transport to the Emergency Department	**4.02** Mode of Transport	**EDisposition.16** EMS Transport Method **EDisposition.18** Additional Transport Mode Descriptors **ETimes.11** Patient Arrived at Destination Date/Time **ETimes.06** Unit Arrived on Scene Date/Time	Mode of Transport to the Emergency Department (Includes estimated time of arrival)	1.3.6.1.4.1.19376.1.5.3.1.1.10.3.2
Advance Directives	**Not Available**	**EHistory.05** Advance Directives	Advance Directives	1.3.6.1.4.1.19376.1.5.3.1.3.34
Pertinent Insurance Information	**3.01** Insurance Coverage or Other Expected Source of Payment	**EPayment.01** Primary Method of Payment	Payers	1.3.6.1.4.1.19376.1.5.3.1.1.5.3.7
Sending Facility	**Not Available**	**EScene.12** Incident Facility or Location Name	Sending Facility	1.3.6.1.4.1.19376.1.5.3.1.1.25.2.1
Receiving Facility	**8.05** Facility Receiving ED Patient	**EDisposition.01** Destination / Transferred To, Name	Receiving Facility	1.3.6.1.4.1.19376.1.5.3.1.1.25.2.2

Y.7-2 Interfacility Transport Content Module

During a transport described in Use Case 2 that begins at one healthcare facility and ends at another healthcare facility, data elements located in Table X.7-2 must be included with data elements from Table X.7-1.

Table Y.7-2 Interfacility Transport Data Element Index

Data Elements	DEEDS	NEMSIS v3	PCC Template	PCC Template ID
Diet & Nutrition (NPO)	**Not Available**	**EHistory.21** Last Oral Intake	Diet & Nutrition (NPO)	1.3.6.1.4.1.193 76.1.5.3.1.3.33
Extra Attendants Information	**Not Available**	**EPayment.41** Specialty Care Transport Care Provider	Extra Attendants Information	1.3.6.1.4.1.193 76.1.5.3.1.1.25 .2.6
Invasive Airway	**Not Available**	**EProtocols.01** (1) Protocols Used	Invasive Airway	1.3.6.1.4.1.193 76.1.5.3.1.1.25 .2.7
Isolation Status	**Not Available**	**EPayment.50** (038.90) EMS Condition Code	Isolation Status	1.3.6.1.4.1.193 76.1.5.3.1.1.25 .2.8
Patient Care Devices	**Not Available**	**DDevice.02** Device Name or ID	Patient Care Devices	1.3.6.1.4.1.193 76.1.5.3.1.1.5. 3.5
Provider Level	**Not Available**	**DConfiguration. 02** State Certification Licensure Levels	Provider Level	1.3.6.1.4.1.193 76.1.5.3.1.1.25 .2.9
Provider Orders	**Not Available**	**EMedications.11** (4) Medication Authorization **EProcedures.11** (4) Procedure Authorization	Provider Orders	1.3.6.1.4.1.193 76.1.5.3.1.1.20 .2.1
Restraints	**Not Available**	**EPayment.50** (298.90) EMS Condition Code	Restraints	1.3.6.1.4.1.193 76.1.5.3.1.1.25 .2.10
Ventilator Usage	**Not Available**	**DDevice.03** (19) Medical Device Type	Ventilator Usage	1.3.6.1.4.1.193 76.1.5.3.1.1.25 .2.11

Transport Summary Definitions

Share Content (Limited)

During transport in Use Case 2, a system must be able to share a limited dataset with the content consumer. This dataset will contain limited pertinent information which is mostly objective. This data includes current vital signs, stat labs and current medication dosages to name a few.

Share Content (Final)

During transport in Use Case 2 a large amount of data, both subjective and objective is collected. This dataset will be shared with the content consumer in its entirety according to the defined dataset. This information will include data shared during the transaction Share Content (Limited).

Glossary

Fixed Wing *– Any transport by airplane*

Rotor Wing *– Any transport by helicopter*

NPO *– Nothing by mouth*

Transport Medicine *– Any field of medicine dealing specifically with an out of care setting environment or restructured to apply to an out of care setting environment.*

Volume 2 – Transactions and Content Modules

5.0 Namespaces and Vocabularies

5.1 IHE Format Codes

Profile	Format Code	Media Type	Template ID
NA	urn:ihe:pcc:trs:2011	text/xml	1.3.6.1.4.1.19376.1.5.3.1.1.25.1.1
EMS Transport Summary (ETS)	urn:ihe:pcc:ets:2011	text/xml	1.3.6.1.4.1.19376.1.5.3.1.1.25.1.2
Interfacility Transport Summary (ITS)	urn:ihe:pcc:its:2011	text/xml	1.3.6.1.4.1.19376.1.5.3.1.1.25.1.3

6.0 PCC Content Modules

6.3 HL7 Version 3.0 Content Modules

6.3.1 CDA Document Content Modules

6.3.1.A Transport Record Summary Specification 1.3.6.1.4.1.19376.1.5.3.1.1.25.1.1

The Transport Record Summary document content module is a Medical Summary and inherits all header constraints from Medical Summary (1.3.6.1.4.1.19376.1.5.3.1.1.2). The intention of this document content module is to provide a base from which other document content modules may be derived.

6.3.1.A.1 Format Code

The XDSDocumentEntry format code for this content is **“urn:ihe:pcc:trs:2011”**

6.3.1.A.2 LOINC Code

The LOINC code for this document is **XX-TRS**

6.3.1.A.3 Standards

CCD	ASTM/HL7 Continuity of Care Document
CDAR2	HL7 CDA Release 2.0
LOINC	Logical Observation Identifiers, Names and Codes
DEEDS	Data Elements for Emergency Department Systems
NEMSIS	National EMS Information Sytem

6.3.1.A.4 Specification

This section references content modules using Template Id as the key identifier. Defintions of the modules are found in either:

IHE Patient Care Coordination Volume 2: Final Text

IHE PCC CDA Content Modules Supplement

Table 6.3.1.A.4-1 Transport Record Summary Specification

Section Name	Section Template ID	Mandatory Inclusion Flag Note 1	Conformance Note 1	Cardinality Note 1	Volume 2 Location
Chief Complaint	1.3.6.1.4.1.19376.1.5.3.1.1.13.2.1	M	R	[1..1]	PCC TF-2:6.3.3.1.3
Medications Given	1.3.6.1.4.1.19376.1.5.3.1.3.21		R	[0..1]	PCC TF-2:6.3.3.3.3
Reason for Referral	1.3.6.1.4.1.19376.1.5.3.1.3.1	M	R	[1..1]	PCC TF 2:6.3.3.1.1
History Present Illness	1.3.6.1.4.1.19376.1.5.3.1.3.4		R	[1..1]	PCC TF-2:6.3.3.2.1
History of Pregnancies	1.3.6.1.4.1.19376.1.5.3.1.1.5.3.4		R		PCC TF-2:6.3.3.2.18
Acuity Assessment	1.3.6.1.4.1.19376.1.5.3.1.1.13.2.2		R	[1..1]	PCC CDA Content Modules: 6.3.3.1.10
Active Problems	1.3.6.1.4.1.19376.1.5.3.1.3.6	M	R	[1..1]	PCC CDA Content Modules:6.3.3.9.6
Current Medications	1.3.6.1.4.1.19376.1.5.3.1.3.19		R	[0..1]	PCC TF-2:6.3.3.3.1
Allergies	1.3.6.1.4.1.19376.1.5.3.1.3.13		R	[0..1]	PCC TF-2:6.3.3.2.11
Immunizations	1.3.6.1.4.1.19376.1.5.3.1.3.23			[0..1]	PCC TF-2:6.3.3.3.5
Pertinent Review of Systems	1.3.6.1.4.1.19376.1.5.3.1.3.18	M	R	[1..1]	PCC TF-2:6.3.3.2.16
Family History	1.3.6.1.4.1.19376.1.5.3.1.3.14			[0..1]	PCC TF-2:6.3.3.2.12
Social History	1.3.6.1.4.1.19376.1.5.3.1.3.16			[0..1]	PCC TF-2:6.3.3.2.14
Coded Physical Examination (Includes Required Coded Vital Signs - 1.3.6.1.4.1.19	1.3.6.1.4.1.19376.1.5.3.1.1.9.15.1	M	R	[1..1]	PCC TF-2:6.3.3.4.2

Section Name	Section Template ID	Mandatory Inclusion Flag[Note 1]	Conformance [Note 1]	Cardinality [Note 1]	Volume 2 Location
376.1.5.3.1.1.5.3.2)					
List of Surgeries	1.3.6.1.4.1.19376.1.5.3.1.3.11		R	[0..1]	PCC TF 2:6.3.3.2.9
Hospital Studies Summary	1.3.6.1.4.1.19376.1.5.3.1.3.29		R	[0..*]	PCC TF 2:6.3.3.5.3
Care Plan (new meds labs, or x-rays ordered)	1.3.6.1.4.1.19376.1.5.3.1.3.31	M	R	[1..1]	PCC TF 2:6.3.3.6.1
Mode of Transport to the Emergency Department (Includes estimated time of arrival)	1.3.6.1.4.1.19376.1.5.3.1.1.10.3.2	M	R	[1..1]	PCC TF-2:6.3.3.6.7
Advance Directives	1.3.6.1.4.1.19376.1.5.3.1.3.34		R	[0..1]	PCC TF-2:6.3.3.6.5
Payers	1.3.6.1.4.1.19376.1.5.3.1.1.5.3.7		R	[1..1]	PCC TF 2:6.3.3.7.1
Sending Facility	1.3.6.1.4.1.19376.1.5.3.1.1.25.2.1	M	R	[1..1]	PCC CDA Content Modules: 6.3.3.7.6
Receiving Facility	1.3.6.1.4.1.19376.1.5.3.1.1.25.2.2	M	R	[1..1]	PCC CDA Content Modules: 6.3.3.7.7

Note 1: In an attempt to clarify our documentation and required fields, we have adopted a method similar in nature to that of HL7. This notation states: If a field has a Mandatory Inclusion Flag, it is required and CAN NOT BE NULL, if it has an R under conformance, it must be present, but CAN BE NULL. Cardinality shows if multiple entries of a section are allowed.

6.3.1.A.5 Conformance

CDA Release 2.0 documents that conform to the requirements of this content module shall indicate their conformance by the inclusion of the appropriate <templateId> elements in the header of the document. This is shown in the sample document below. A CDA Document may conform to more than one template. This content module inherits from the Medical Summary content module, and so must conform to the requirements of that template as well, thus all <templateId> elements shown in the example below shall be included.

```
<ClinicalDocument xmlns='urn:hl7-org:v3'>
 <typeId extension="POCD_HD000040" root="2.16.840.1.113883.1.3"/>
 <templateId root='1.3.6.1.4.1.19376.1.5.3.1.1.25.1.1'/>
 <id root=' ' extension=' '/>
 <code code='XX-TRS' displayName='Transport Record Summary'
  codeSystem='2.16.840.1.113883.6.1' codeSystemName='LOINC'/>
 <title>Transport Record Summary</title>
 <effectiveTime value='20090506012005'/>
 <confidentialityCode code='N' displayName='Normal'
  codeSystem='2.16.840.1.113883.5.25' codeSystemName='Confidentiality' />
<languageCode code='en-US'/>
   :
 <component><structuredBody>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.1.13.2.1'/>
    <!-- Required Chief Complaint Section content -->
   </section>
  </component>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.3.21 '/>
    <!-- Required Medications Given Section content -->
   </section>
  </component>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.3.1 '/>
    <!-- Required Reason for Referral Section content -->
   </section>
  </component>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.3.4  '/>
    <!— Required History of Present Illness Section content -->
   </section>
  </component>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.1.5.3.4  '/>
    <!— Conditional History of Pregnancies Section content -->
   </section>
  </component>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.1.13.2.2  '/>
    <!— Required Acuity Assessment Section content -->
   </section>
  </component>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.3.6  '/>
    <!-- Required Active Problems Section content -->
   </section>
  </component>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.3.19 '/>
    <!-- Required Current Medications Section content -->
   </section>
  </component>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.3.13 '/>
    <!-- Required Allergies Section content -->
   </section>
  </component>
  <component>
   <section>
```

```
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.3.23 '/>
    <!-- Immunizations Section content -->
   </section>
  </component>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.3.18 '/>
    <!-- Required Pertinent Review of Systems Section content -->
   </section>
  </component>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.3.14 '/>
    <!— Family History Section content -->
   </section>
  </component>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.3.16 '/>
    <!— Social History Section content -->
   </section>
  </component>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.1.9.15.1'/>
    <!-- Required Coded Physical Examination Section content -->
   </section>
  </component>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.3.11'/>
    <!-- Required List of Surgeries Section content -->
   </section>
  </component>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.3.29'/>
    <!-- Required Hospital Studies Summary Section content -->
   </section>
  </component>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.3.31'/>
    <!-- Required Care Plan Section content -->
   </section>
  </component>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.1.10.3.2'/>
    <!-- Required Mode of Transport Section content -->
   </section>
  </component>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.3.34 '/>
    <!-- Required Advanced Directives Section content -->
   </section>
  </component>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.1.5.3.7'/>
    <!-- Required Payers Section content -->
   </section>
  </component>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.1.25.2.1 '/>
    <!-- Required Sending Facility Section content -->
   </section>
  </component>
  <component>
```

```
    <section>
     <templateId root='1.3.6.1.4.1.19376.1.5.3.1.1.25.2.2'/>
     <!—Required Receiving Facility Section content -->
    </section>
   </component>
  </component>
```

Figure 6.3.1.A.5-1 Sample Transport Record Summary Document

6.3.1.B EMS Transport Summary Specification 1.3.6.1.4.1.19376.1.5.3.1.1.25.1.2

The EMS Transport Summary contains a record of the “referral summary” usually received during transport. This document content module is a Transport Record Summary and inherits all header constraints from Transport Record Summary. (1.3.6.1.4.1.19376.1.5.3.1)

6.3.1.B.1 Format Code

The XDSDocumentEntry format code for this content is “**urn:ihe:pcc:ets:2011**”

6.3.1.B.2 LOINC Code

The LOINC code for this document is **XX-ETS**

6.3.1.B.3 Standards

CCD	ASTM/HL7 Continuity of Care Document
CDAR2	HL7 CDA Release 2.0
LOINC	Logical Observation Identifiers, Names and Codes
DEEDS	Data Elements for Emergency Department Systems
NEMSIS	National EMS Information Sytem

6.3.1.B.4 Specification

This section references content modules using Template Id as the key identifier. Defintions of the modules are found in either:

IHE Patient Care Coordination Volume 2: Final Text

IHE PCC CDA Content Modules Supplement

Table 6.3.1.B.4-1 Emergency Transport Summary Specification

Template Name	Section Template ID / Location	Mandatory Inclusion Flag[Note 1]	Conformance[Note 1]	Cardinality[Note 1]	Volume 2 Location
Injury Incident Description	1.3.6.1.4.1.19376.1.5.3.1.1.19.2.1		R	[1..1]	PCC CDA Content Modules:6.3.3.1.10
Mass Casualty Incident	1.3.6.1.4.1.19376.1.5.3.1.1.25.2.3		R	[0..1]	PCC CDA Content Modules: 6.3.3.7.8
Unit Response Level	1.3.6.1.4.1.19376.1.5.3.1.1.25.2.4	M	R	[1..1]	PCC CDA Content Modules: 6.3.3.7.9
Protocols Used	1.3.6.1.4.1.19376.1.5.3.1.1.25.2.5	M	R	[1..*]	PCC CDA Content Modules: 6.3.3.6.21
Intravenous Fluids Administered	1.3.6.1.4.1.19376.1.5.3.1.1.13.2.6		R	[0..1]	PCC CDA Content Modules:6.3.3.8.4

Note 1: In an attempt to clarify our documentation and required fields, we have adopted a method similar in nature to that of HL7. This notation states: If a field has a Mandatory Inclusion Flag, it is required and CAN NOT BE NULL, if it has an R under conformance, it must be present, but CAN BE NULL. Cardinality shows if multiple entries of a section are allowed.

6.3.1.B.5 Conformance

CDA Release 2.0 documents that conform to the requirements of this content module shall indicate their conformance by the inclusion of the appropriate <templateId> elements in the header of the document. This is shown in the sample document below. A CDA Document may conform to more than one template. This content module inherits from the Medical Summary content module, and so must conform to the requirements of that template as well, thus all <templateId> elements shown in the example below shall be included.

```
<ClinicalDocument xmlns='urn:hl7-org:v3'>
 <typeId extension="POCD_HD000040" root="2.16.840.1.113883.1.3"/>
 <templateId root='1.3.6.1.4.1.19376.1.5.3.1.1.25.1.2'/>
 <id root=' ' extension=' '/>
 <code code='XX-ETS' displayName='EMS Transport Summary'
  codeSystem='2.16.840.1.113883.6.1' codeSystemName='LOINC'/>
 <title>EMS Transport Summary</title>
 <effectiveTime value='20090506012005'/>
 <confidentialityCode code='N' displayName='Normal'
  codeSystem='2.16.840.1.113883.5.25' codeSystemName='Confidentiality' />
<languageCode code='en-US'/>
   :
 <component><structuredBody>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.1.19.2.1 '/>
    <!-- Required If Known Injury Incident Description Section content -->
   </section>
  </component>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.1.25.2.3 '/>
    <!-- Required If Known Mass Casualty Incident Section content -->
   </section>
  </component>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.1.25.2.4 '/>
    <!-- Required Unit Response Level Section content -->
   </section>
  </component>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.1.25.2.5 '/>
    <!-- Required Protocols Used Section content -->
   </section>
  </component>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.1.13.2.6 '/>
    <!-- Required If Known Intravenous Fluids Administered Section content --
>
   </section>
  </component>
 </component>
```

Figure 6.3.1.B.5-1 Sample Emergency Transport Summary Document

6.3.1.C Interfacility Transport Summary Specification 1.3.6.1.4.1.19376.1.5.3.1.1.25.1.3

The Interfacility Transport Summary contains a record of the “referral summary” usually received during transport. This document content module is a Transport Record Summary and inherits all header constaints from Transport Record Summary. (1.3.6.1.4.1.19376.1.5.3.1)

6.3.1.C.1 Format Code

The XDSDocumentEntry format code for this content is “**urn:ihe:pcc:its:2011”**

6.3.1.C.2 LOINC Code

The LOINC code for this document is XX-ITS

6.3.1.C.3 Standards

CCD	ASTM/HL7 Continuity of Care Document
CDAR2	HL7 CDA Release 2.0
LOINC	Logical Observation Identifiers, Names and Codes
DEEDS	Data Elements for Emergency Department Systems
NEMSIS	National EMS Information Sytem

6.3.1.C.4 Specification

This section references content modules using Template Id as the key identifier. Defintions of the modules are found in either:

IHE Patient Care Coordination Volume 2: Final Text

IHE PCC CDA Content Modules Supplement

Table 6.3.1.B.4-1 Emergency Transport Summary Specification

Template Name	Section Template ID	Mandatory Inclusion Flag Note 1	Conformance Note 1	Cardinality Note 1	Volume 2 Location
Diet & Nutrition (NPO)	1.3.6.1.4.1.19376.1.5.3.1.3.33		R	[0..1]	PCC TF 2:6.3.3.6.4
Extra Attendants Information	1.3.6.1.4.1.19376.1.5.3.1.1.25.2.6		R	[0..1]	PCC CDA Content Modules: 6.3.3.7.10
Invasive Airway	1.3.6.1.4.1.19376.1.5.3.1.1.25.2.7		R	[0..1]	PCC CDA Content Modules: 6.3.3.6.22
Isolation Status	1.3.6.1.4.1.19376.1.5.3.1.1.25.2.8		R	[0..1]	PCC CDA Content Modules: 6.3.3.2.56
Patient Care Devices	1.3.6.1.4.1.19376.1.5.3.1.1.5.3.5			[0..*]	PCC TF 2:6.3.3.2.19
Provider Level	1.3.6.1.4.1.19376.1.5.3.1.1.25.2.9	M	R	[1..1]	PCC CDA Content Modules: 6.3.3.7.11
Provider Orders	1.3.6.1.4.1.19376.1.5.3.1.1.20.2.1		R	[0..1]	PCC CDA Supplement 2:6.3.3.6.11
Restraints	1.3.6.1.4.1.19376.1.5.3.1.1.25.2.10		R	[0..1]	PCC CDA Content Modules: 6.3.3.2.57
Ventilator Usage	1.3.6.1.4.1.19376.1.5.3.1.1.		R	[0..1]	PCC CDA Content

Template Name	Section Template ID	Mandatory Inclusion Flag [Note 1]	Conformance [Note 1]	Cardinality [Note 1]	Volume 2 Location
	25.2.11				Modules: 6.3.3.6.23

Note 1: In an attempt to clarify our documentation and required fields, we have adopted a method similar in nature to that of HL7. This notation states: If a field has a Mandatory Inclusion Flag, it is required and CAN NOT BE NULL, if it has an R under conformance, it must be present, but CAN BE NULL. Cardinality shows if multiple entries of a section are allowed.

6.3.1.C.5 Conformance

CDA Release 2.0 documents that conform to the requirements of this content module shall indicate their conformance by the inclusion of the appropriate <templateId> elements in the header of the document. This is shown in the sample document below. A CDA Document may conform to more than one template. This content module inherits from the Medical Summary content module, and so must conform to the requirements of that template as well, thus all <templateId> elements shown in the example below shall be included.

```
<ClinicalDocument xmlns='urn:hl7-org:v3'>
 <typeId extension="POCD_HD000040" root="2.16.840.1.113883.1.3"/>
 <templateId root='1.3.6.1.4.1.19376.1.5.3.1.1.25.1.3'/>
 <id root=' ' extension=' '/>
 <code code='XX-ITS' displayName='Interfacility Transport Summary'
  codeSystem='2.16.840.1.113883.6.1' codeSystemName='LOINC'/>
 <title>Interfacility Transport Summary</title>
 <effectiveTime value='20090506012005'/>
 <confidentialityCode code='N' displayName='Normal'
  codeSystem='2.16.840.1.113883.5.25' codeSystemName='Confidentiality' />
<languageCode code='en-US'/>
   :
 <component><structuredBody>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.3.33’/>
    <!—Required If Known Diet & Nutrition Section content -->
   </section>
  </component>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.1.25.2.6 ’/>
    <!-- Required Extra Attendants Information Section content -->
   </section>
  </component>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.1.25.2.7 ’/>
    <!-- Required Invasive Airway Section content -->
   </section>
  </component>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.1.25.2.8 ’/>
    <!-- Required If Known Isolation Status Section content -->
   </section>
  </component>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.1.5.3.5 ’/>
    <!—Patient Care Devices Section content -->
   </section>
  </component>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.1.25.2.9 ’/>
    <!—Required Provider Level Section content -->
   </section>
  </component>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.1.20.2.1 ’/>
    <!—Required If Known Provider Orders Section content -->
   </section>
  </component>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.1.25.2.10 ’/>
    <!—Required If Known Restraints Section content -->
   </section>
  </component>
  <component>
   <section>
    <templateId root='1.3.6.1.4.1.19376.1.5.3.1.1.25.2.11’/>
    <!-- Required Ventilator Usage Section content -->
   </section>
  </component>
 </component>
```

Figure 6.3.1.C.5-1 Sample Interfacility Transport Document

6.3.2 CDA Header Content Modules

NA

6.3.3 CDA Section Content Modules

See PCC Technical Framework Volume 2 or CDA Content Modules Supplement for Section Content Module definitions.

6.3.4 CDA Entry Content Modules

NA

6.5 PCC Value Sets

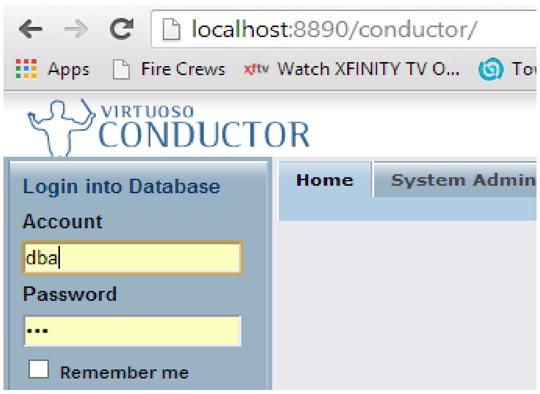
NA

7.2 Appendix B: Argus Medical Record Transport System User Manual

User Manual

7.2.1 Setting up the Environment

In order to run the Transport Record Interface, one must first install Virtuoso Server. Virtuoso is available online at http://www.openlinksw.com/. Virtuoso must be installed using default server settings for the program to run properly. The database must be located at: localhost:1111
Once installed and running, log in at http://localhost:8890 with default ID: dba PW: dba.

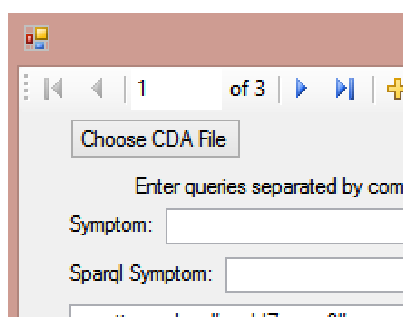


Then choose the Linked Data tab at top right, then Quad Store Upload on sub menu.

Click Choose File and navigate to Ontology RDF File.
You can change the name of the Named Graph IRI. Click Upload

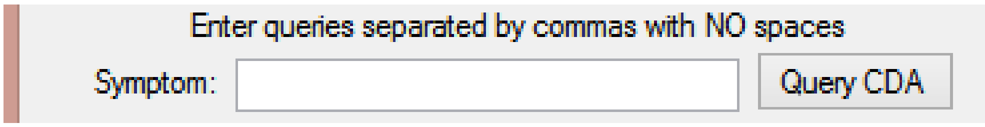
7.2.2 Running the Program

Click Choose CDA File to open the appropriate Clinical Document Architecture (CDA) file for the patient.
You can search based on current patient symptoms or diseases in the health record.



7.2.3 Symptom Search

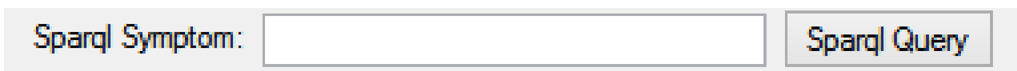
Type in the name of any symptom in the symptom field. You can search multiple symptoms, by separating each term by a comma, but NO spaces. Click Query CDA.



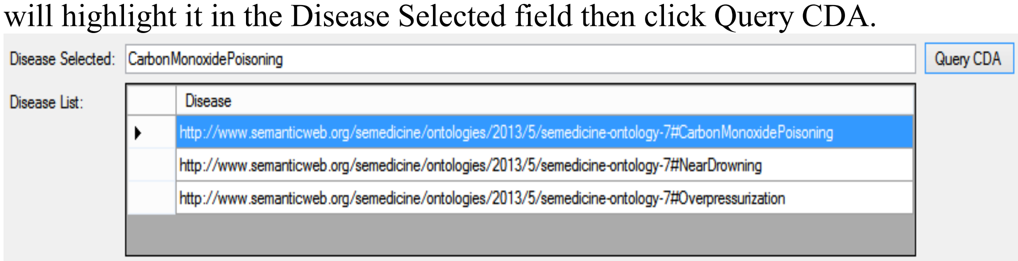
A list of sections in the selected CDA document will appear in the output window.

7.2.4 Disease Search

You can also search the CDA document by probable dise ase based on the patient's current symptoms. Type in the name of a symptom in the Sparql Symptom field and click Sparql Query.



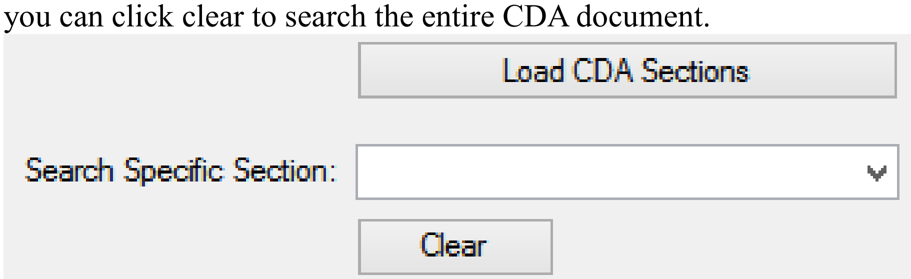
The results of this sparql query appear below the output box in the Disease List and Disease Selected fields. You can then click which disease you want to query the CDA documents with, by selecting it from the Disease List, which will highlight it in the Disease Selected field then click Query CDA.



A list of sections in the selected CDA document will appear in the output window.

7.2.5 Additional Search Options

You can narrow your search by clicking Load CDA Section and then choosing which section of the current CDA document you wish to search. At any time you can click clear to search the entire CDA document.



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12. **Framework, The Connecting for Health Common.** *Health Information Exchange: Architecture Implementation Guide.* 2009.

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Curriculum Vitae

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CAREER OBJECTIVE

Leading innovative and challenging projects in which integrate all domains of Health IT and meet my competencies, capabilities, skills, education and experience.

Vision:

To develop innovative technology to serve the secure healthcare information systems field, through cross experience in the clinical, research and academic fields.

Research Interests:

- Interoperability
- Medical Ontologies
- Semantic Queries
- Context-Aware Systems
- Public Health Informatics
- Electronic Health Records

EDUCATION

December 2013: **Towson University**
Towson, MD

Doctor of Science in Information Technology
Dissertation - *"Electronic Health Record Interoperability*

Across Transport Medicine"
Doctor of Science Program, Department of Computer & Information Sciences

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May 2006: **Towson University**
Towson, MD

Masters of Science: Applied Information Systems Management

May 2004: **University of Maryland**
Baltimore, MD

Bachelors of Science: Information Systems Management

May 2000: **Loyola High School**, Towson, MD
Diploma

IT PROFESSIONAL EXPERIENCE

January 2013 - Present: **Epic EHR Implementation**
Johns Hopkins Hospital
Baltimore, MD

- Provide Implementation Support
- Ambulatory & Inpatient EHR Support and Training
- Assist Clinicians with Transition

January 2011 - Present: **Standards & Interoperability Framework Initiative Member**
Office of the National Coordinator

Washington, DC

- Clinical Document Architecture Consolidation
- Transitions of Care Exchange
- Certificate Interoperability Initiative

August 2008 - Present:

Integration the Healthcare Enterprise Profile Author
Integrating the Healthcare Enterprise
Chicago, IL

- Transport Record Summary Profiles
- Interoperability Testing using CDA modeling
- Patient Care Coordination
- IT Infrastructure

August 2008 - Present:

Interoperability Showcase Coordinator
Healthcare Information and Management Systems Society
Chicago, IL

- Manage docents for interoperability use cases
- Technical project manager for interoperability use cases

May 2000 - Present:

IT Manager
DePalo & Sons, Inc.
Baltimore, Maryland

- Manage the proprietary FACTS enterprise software.
- Manage all internet related B2C products.
- SQL database management.
- Manage website operations.
- Implement interfaces between dealers and vendors.
- Develop Customer Relationship Management

software.
- Current research and development of RFID inventory tracking

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CERTIFICATIONS

November 2011: **Project Management Institute**
Newtown Square, PA

Project Management Professional (PMP) Certification #1470917

May 2004: **Maryland Institute of Emergency Medical Services System**
Baltimore, MD

Licensed Paramedic # 0107986

May 2004: **National Registry of Emergency Medical Technicians**
Columbus, OH

Nationally Registered Licensed Paramedic # P0988255

October 2000 - 2002: **University of Maryland**
College Park, MD

Certification, Fire Officer III
Certification, Fire Officer II
Certification, Fire Officer I
Certification, Rope Rescue Technician
Certification, Instructor II
Certification, Fire Pumps Specialist
Certification, Fire Fighter II
Certification, Fire Fighter I
Certification, Rescue Technician
Certification, Swiftwater Rescue

OTHER PROFESSIONAL EXPERIENCE

March 2011 - Present: **Pediatric Advanced Life Support Instructor**
Johns Hopkins University School of Medicine
Baltimore, MD

May 2009 - Present: **Pilot**
Civil Air Patrol
Baltimore, MD

License #3379214

November 2007 - Present: **Critical Care Transport Paramedic**
Johns Hopkins Hospital
Baltimore, MD

October 2007 - Present: **Public Safety & SCUBA Diving Instructor**
Tricks of the Trade
Baltimore, MD

Train various fire department and private dive teams in Public Safety Diving as well as private individuals in recreational diving. Certification Agencies:

- PADI – 234756
- ERDI – 12672
- SDI – 12672
- TDI - 12672

August 2005 - Present: **MICRB Level II Instructor**
Maryland Fire and Rescue Institute
University of Maryland
College Park, MD

Instruct fire department members to become EMTs and Paramedics.

August 2005 - Present: **Basic Life Support Instructor**
Baltimore County Fire Department
Baltimore County, MD

Provider AHA CPR & First Aid Instruction

September 2004 – December 2004: **Spanish Teacher**, Towson, MD
Baltimore County Public Schools

Taught high school honors Spanish during the fall semester as a substitute.

May 2000 – Present: **Treasurer / Secretary**
Laughter Arts Foundation, Inc.
Reisterstown, MD

The Laughter Arts Foundation, Inc. is a non-profit 501c-3 organization to promote the variety arts through educational workshops, subsidized entertainment and scholarships. I am currently on the Board of Directors acting as the Treasurer and Secretary for the organization.

March 2000 - Present: **Volunteer Paramedic Fire Officer**
Baltimore County Volunteer Firemen's Association
Baltimore County Fire Department
Baltimore, MD

Perform various skills including paramedical pre-hospital emergency care, fire suppression, tactical rescue, swiftwater rescue and dive rescue.

June 1998 - Present: **Self Employed Variety Entertainer**
Tricks of the Trade

Baltimore, MD

I have been performing since the summer of 1998 as a self-employed entertainer for my company called Tricks of the Trade. Performances range from 5-90 minutes. My show is called Fire & Steel and combines fire stunts and sword swallowing as a comic byline through a show filled with physical comedy routines.

PUBLICATIONS & CONFERENCE PAPERS

Improving Patient Care in Transport Medicine through an Ontological Approach. DePalo, Philip., Park, Kyun Eun., Song, Yeong-Tae. 7th International Conference on Ubiquitous Information Management and Communication, January 9-11 2014, Siem Reap, Cambodia. *in press*.

Healthcare Interoperability: CDA Documents Consolidation Using Transport Record Summary Construction. DePalo, Philip., Park, Kyung Eun., Song, Yeong-Tae. 15th International Conference on Human-Computer Interaction, July 21-26 2013, Las Vegas, Nevada. *Springer Computer Science Editorial, Volume 8005*.

Healthcare Interoperability through Enterprise Architecture. DePalo, Philip., Song, Yeong-Tae. 6th International Conference on Ubiquitous Information Management and Communication, February 20-22 2012, Kuala Lumpur, Malaysia. *Association for Computing Machinery, Article 71*.

Implementing Interoperability using an IHE Profile for Interfacility Patient Transport. DePalo, Philip., Song, Yeong-Tae. ACIS Conference on Computers, Networks, Systems, and Industrial Engineering, May 23-25 2011, Jeju Island, Korea.

Transport Record Summary Profiles. DePalo, Philip., Integrating the Healthcare Enterprise, May 6 2011, Chicago, Illinois. IHE PCC Public Comment Profiles 2010-2011.

E-Learning in Health Information Technology. Song, Yeong-Tae., DePalo, Philip., GUIDE International Workshop 2010, March 17-18 2010, Rome, Italy. Proceedings of the GUIDE Workshop 2010.

INTERNATIONAL INVITATIONAL LECTURES

Standards and Interoperability: *in a world where sharing information is critical.*
Healthcare Information and Management Systems Society Conference, November 3rd, 2011.

PROFFESIONAL MEMBERSHIPS

American Medical Informatics Association
Healthcare Information and Management Systems Society
Integrating the Healthcare Enterprise
Health Level 7
Project Management Institute

SKILLS

Skill	**Level**	**Experience**
ASP.NET	Intermediate	5 years
C#	Intermediate	5 years
MSSQL	Intermediate	11 years
CDA Modeling	Intermediate	4 years
HL7	Intermediate	4 years
MySQL	Intermediate	11 years
Web Development	Expert	11 years
Network Management	Intermediate	11 years
Project Management	Advanced	7 years

LANGUAGES

Language	**Level**
English	Expert
Spanish	Conversational
