Healthcare Interoperability: CDA Documents Consolidation Using Transport Record Summary (TRS) Construction

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Abstract. Thanks to recent medical record standards and distributed technology, the exchange of medical documents has become readily available. Healthcare institutions are able to share documents with other providers; however, patients who require medical transport are still subject to rudimentary exchange of information through verbal reports and outdated hand written medical notes. An ongoing exchange of medical documents between patient transport units and the facilities they serve would help reduce medical errors. Our approach 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 proposes 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.

Keywords: Enterprise architecture, electronic health records (EHR), electronic health record, hospital IT management, health information technology, interoperability, clinical document architecture (CDA), Health Level Seven (HL7), Transport Record Summary (TRS).

1 Introduction

Sharing a single medical record among medical facilities is the goal of the US Government defined meaningful use directive. It is not only the adoption of the electronic health record (EHR), but the ability to use it in multiple specific ways. Blumenthal [1] 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 [2]

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estimates 27,500 patients are transported by the Johns Hopkins Lifeline Critical Care Transport team. This accounts for only one hospital in one state. Currently transport medicine clinicians do not have access to patients' electronic health records. Boockvar [3] 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 retrieve current medical documents on a patient requiring transport, reducing errors and improving patient outcomes through more directed cares and accurate medical histories.

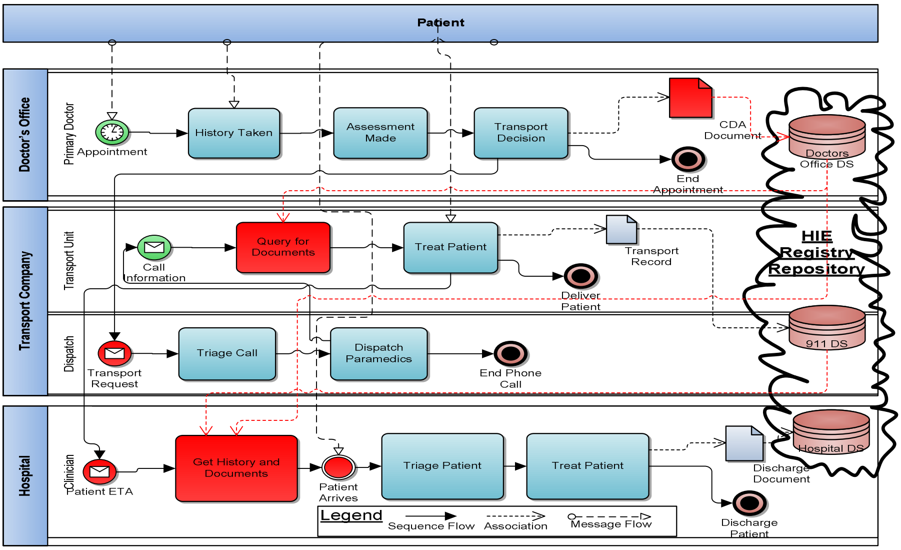

Fig. 1. Proposed Medical Transport Business Process Model

We propose new methods to querying medical documents during patient transport and consolidating them into a single XML compilation based on relevant information for the specific problem. This query uses the local HIE and the eHealth Exchange, formerly the Nationwide Health Information Network [4]. Through these two step processes, we form a machine readable XML-based CDA document that provides up-to-date information of the patient.

In section 2 we review meaningful use and explain its objectives and how our methods meet some of these objectives and provide benefits to providers. In section 3, we show our analysis methods used to develop our proposal through various enterprise architecture scenarios affecting health IT. Section 4 details our plan for medical record consolidation and proposes a tool for the construction. Section 5 and 6 wrap up our findings along with our plan to implement the proposed tool.

2 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 concentrate on stage one for our proposal. There are 15 specific criteria for Meaningful Use [6] stage one. Among these basic criteria includes computerized medication order entry, drug-drug and drug-allergy check lists, generate and transmit electronic prescriptions, and maintaining medication, problem and allergy list. Many larger institutions will have some degree of meaningful use already achieved through current systems and will 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.

3 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 to retrieve patient's health information during the transport.

3.1 Business Scenario

Fig 1. shows the proposed business process model. The darker colored sections indicate where changes have been made to the current 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 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 estimated time of arrival (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) [8] which we previously developed. They are then able to begin to treat and determine the appropriate care plan for this patient upon arrival, which may include an additional medical transport to a higher level of care.

3.2 Information Scenario

Information during the 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 messaging resources using on call type and location to dispatch a transport unit using EDXL Sharp [9]. The transport unit 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 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, but highlights 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.

3.3 Application Scenario

The doctor's office can view the Personal Health Record for updated information through their 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 the location information which can be acquired through the Enhanced 911 (E911), permitting emergency response personnel to pinpoint the location of a cellular telephone caller anywhere in the United States following the events of "9/11" [10]. The CAD determines the closest and appropriate level of transport unit.

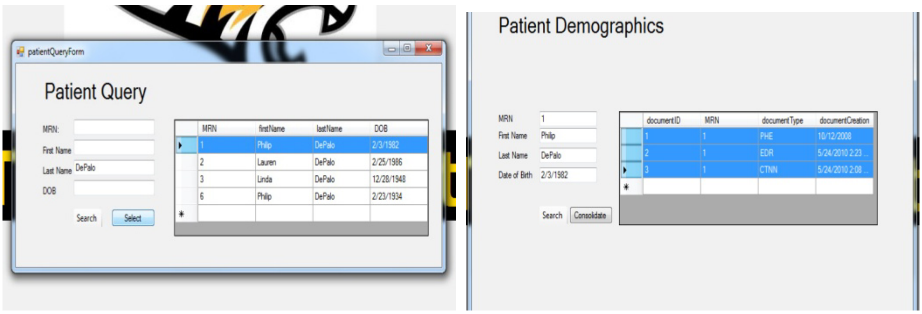

Fig. 2. Transport Application Interface Screenshots

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 Fig 2. This EHR will also update the HIE with a new TRS document based on the care provided.

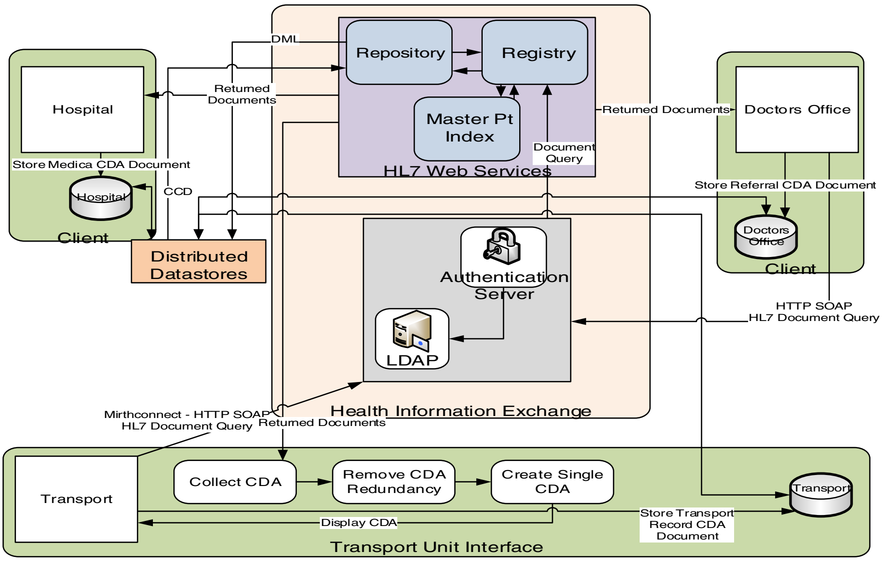

Fig. 3. Interoperable Transport Architecture

3.4 Technical Scenario

Fig 3. shows the applicable software architecture along with the messages to post and retrieve documents. The client application interface is used to 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 [11] and mirthconnect [12] 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 [13].

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.

Chiu [14] 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. 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 [15]. The clinical documents are organized into three levels: the narrative documents, section level content and entries for unique coding and semantics [16]. 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 complete, the repository will send an error.

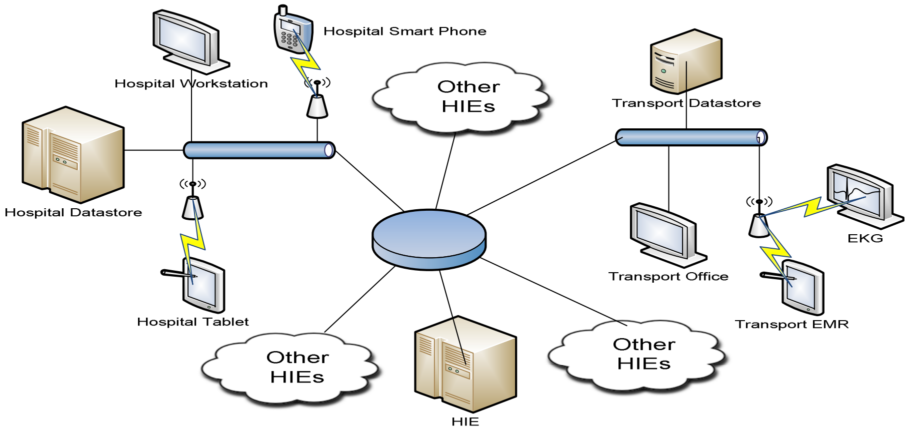

Fig. 4. Network Model

Fig 4. shows that collection starts at the personal medical environment of patient monitoring devices such as an Electrocardiography or EKG. These can be connected via USB or Bluetooth methods and even low powered local area networks such as ZigBee Health [17]. 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 more unlikely given the mobile environment of the service.

Databases can consist of MSSQL servers and messages 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 environment of 911 and interfacility transport providing waterproof, impact proof and drop proof systems.

4 CDA Document Consolidation

A CDA document is an XML-based clinical document standard to be exchanged across health care community [15], [18], [19]. 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 [15]. The CDA scheme provides the healthcare interoperability by presenting syntactic standard of clinical documents. Accordingly, the adoption of the CDA document results in enhancing the 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 from each document, and present the single CDA document as described in Fig 5. 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 Fig 6.

4.1 TRS Constructor

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

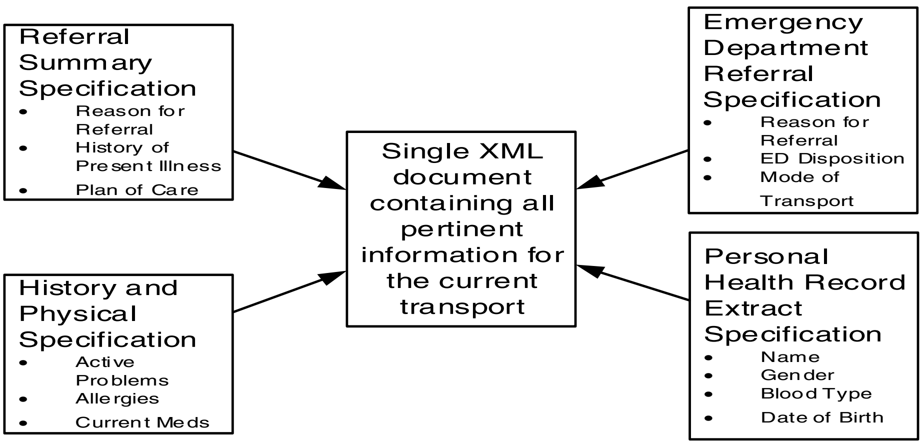

Fig. 5. CDA Document Consolidation

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

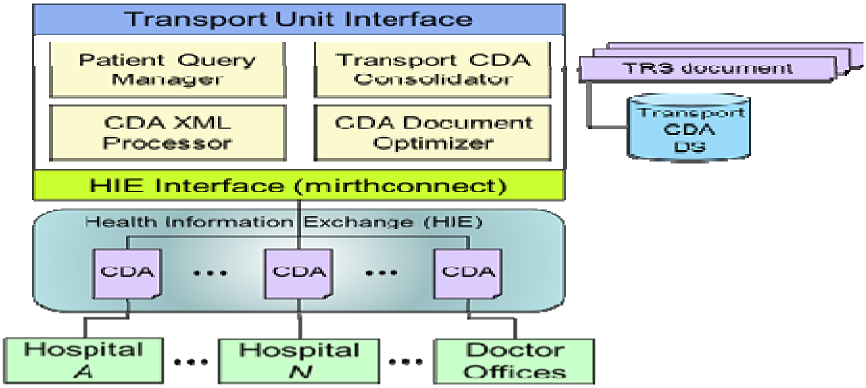

Fig. 6. TRS Constructor with CDA Consolidation

XML-based CDA documents are decomposed by CDA XML parser. Decomposed patient's health records are analyzed to extract appropriate patient records by 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 preliminary CDA document based on the associated symptom and keyword analysis and extended CDA based on semantic analysis. 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 HIE interface which provides HIE connection and is implemented by applying mirthconnect [12], an open source HL7 healthcare integration engine.

4.2 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' />
```

5 Conclusions

In this paper, we have proposed a consolidated single medical record with our TRS constructor using an HL7 interface for the exchange of available CDA documents. This aids institutions in adhering to meaningful use stage one standard that demands maintenance of medication, problem and allergy lists. Creating a report of continuous vital signs through a medical summary of the transport unit's encounter with the patient is also included in stage one. Our document is accessible to other providers and to the patient through their personal health record. This XML document provides up to date information about the current patient and aids in defining immediate treatment and long term care plans. The opportunity for this type of document may not be realized in the controlled environment of a hospital, but in resource poor settings such as medical transports, ease of immediate access to relevant information is paramount.

6 Future Work

Our future direction will be on using semantic queries with the TRS Constructor to build our CDA document. Our ontology based approach will first utilize existing medical protocols to determine differential diagnosis based on a group of symptoms; utilize a combination of measurements through a framework approach that is repeatable, reliable, consistent, complete and optimized. We will then retrieve the available data in the HIE and consolidate it using the TRS constructor based on the patient's particular symptoms.

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