Cross-Domain Information and Service Interoperability

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Abstract

The growing trends towards integrating legacy applications with new systems in a network-centric environment has introduced yet another level of complexity beyond those we witnessed in development of large monolithic systems. In this context, most research challenges focus on interoperability within the same domain. However, provision of cross-domain interoperability among collaborating domains is a new challenge that needs more attention from the research community. Such interoperability requires data and service extraction to obtain common subsets of information and services in collaborating domains, e.g., healthcare and insurance. The first step in achieving such a large interoperability is to follow similar development processes for collaborating domains, which provides homogeneity in their architectures. The second step would be to provide intra-domain and inter-domain semantic interoperability through proprietary and shared ontology systems. In this paper, we address the above challenges through description of a framework that is based on core information standards and terminology systems and employs a guideline to achieve service interoperability among systems of the collaborating domains. A real-world case study of cross-domain interoperability among two domains healthcare and insurance is presented.

KEYWORDS: Cross-domain Interoperability; Standardization; Healthcare; HL7; Legacy System.

1. Introduction

Globalization in information technology requires advancements towards interoperable legacy and new systems in different application domains. In this path, leveraging standards for information representation and communication techniques is inevitable to mitigate the heterogeneity level of the applications.

iiWAS'08, November 24-26, 2008, Linz, Austria

To tackle the complexity of network-centric interoperability, the trend is towards ease of use, vendor / language / platform independency, and in general raising the level of communication abstraction from low-level techniques to provider-independent techniques, and finally to high-level abstractions such as service oriented architecture (SOA). These technologies to a large extent have diminished the problem of interoperability of heterogeneous data among distributed systems. However, a major challenge in interoperability among systems is interpretation of concepts from outside of one's domain of expertise. This emerging need must be addressed by cross-domain facilitators with enough knowledge from each participating domain to establish the required communications. Therefore, the first task is to extract both data and services from participating application domains to allow systems to perform mutual business. The next task is to provide the means for communication of information (syntactic interoperability) and communication of meaning (semantic interoperability) which are achieved through comprehensive and standard information and concept representations and communication through standard messages.

Most IT enabled application domains such as: banking, government, reservation systems and tele-communication suffer from lack of a standard way of communication instead of their vendor's proprietary infrastructure that complicates the heterogeneity problem. In this context, Healthcare domain has already experienced much difficulties in communication among information systems; hence, the responsible organizations have developed a standard way of interoperability through defining comprehensive information and concept representation that will convey a consistent interpretation of semantic concepts.

In this paper, we discuss interoperability provision among legacy software systems within and across application domains, according to standard information, knowledge, and services. We propose the steps for a standard-based process model that allows both legacy and new information systems to communicate as a part of a very large system or system of systems (SoS) [10]. The proposed model consists of two paths for data and service extraction which consequently generates the information that will be used as the content of standard messages. The process applies constraints to identify the appropriate messages to communicate with. The proposed model is based on extending a core and generic subset of a well-defined and standard information model and terminology system, by considering the corresponding models in a second domain. The result would be a mediator information model that will be used for communicating specific messages among systems in both domains. We take HL7 v3 information model RIM in "healthcare domain", and the standard information model ACORD in "insurance domain". We identify the core information model from RIM and extend this core to obtain interoperable information and terminology models to communicate between two domains. We also present a case study as the proof of concept.

The remaining of this paper is structured as follows. Section 2 presents the related work. In Section 3, we briefly introduce healthcare and insurance information standards. The proposed guidelines for standard-based interoperability provision is discussed in Section 4. We introduce our inter-domain data and service interoperability framework in Section 5 and provide more details on data integration steps. Section 6 provides a case study for interoperability of healthcare and insurance domains. Finally in Section 7 we conclude the paper together with a discussion.

2. Related Work

Achieving interoperability among heterogeneous systems is increasingly important in different domains namely airport, healthcare and military. Interoperability standards in airport domain is provided to exchange information about travelers and aircrafts for various purposes. These standards address the issues such as [1]: information exchange model, mapping to database schemas, spatial data standard for facilities, and airport infrastructure environment. Harmonization efforts among these standards aim to fill the gaps between these standards and to allow them to collaborate. Janssen et al. [19] leverages interoperability and try to address interoperability issues in electronic governance. Guijarro [13] also discusses semantic interoperability for electronic governments. Homann et al. [22] propose an interoperability framework for integrating banking systems and present a case study on 2 European banks using web services. According to these articles, the trends are towards achieving standards in semantic interoperability and different domains are developing their own standards; they faced the same problems that healthcare has previously tackled and provided partial solutions. We intend to address these inconsistency issues by generalizing HL7 v3 application development process.

Donachy et al. [20] discuss the requirements for high quality assurance within SOA and grid infrastructures. There are efforts by organizations and software vendors to propose architectures and frameworks for interoperability. CORBA [5], the Common Object Request Broker Architecture, is OMG's open and vendor-neutral architecture and infrastructure that computer applications use to work together over networks. Oracle's Healthcare Transaction Base (HTB) [6] provides the technology means to create a comprehensive patient record that can be shared across institutions and geographic regions, so the patients can be assured that their medical information follows them wherever they go. Motahari et al. [16] propose a conceptual framework for analysing web services interoperability and standards. As opposed to different vendor-based products for interoperability, we suggest to use web services which are globally accepted and the joining their network is very low cost.

Lewis et al. [15] attempt to diagnose the limitations of interoperability standards. They focus on two areas: limitation of these standards to address semantic and organizational levels of interoperability, as well as the need for addressing quality of service. The paper concludes that standards are not enough because of possible extensions and customizations and life cycle of standards. In this paper, we propose a framework to address the problems with standards.

Hogg et al. [18] propose and evaluate an architecture for PPS B2B to take advantage of web services technology and state that web services are a proper technology of choice for reuse and minimization of interoperability efforts. Mykkańnen et al. [17] propose a framework to evaluate interoperability standards with a case study on HL7 v3 messaging standards defined for scheduling subdomain. In general, the methodology and processes offered by HL7 v3 standards can benefit other domains in their software development processes.

Chen et al. [14] review high level aspects of historical (before 2000) enterprise integration architectures and recent interoperability frameworks and state that there is not an ideal framework for interoperability yet. The paper addresses SOA, web services and web based technology platforms as outstanding improvement in technical interoperability. Shetty et al.[21] address design and development of a large scale autonomic system that uses the concepts of model integrated computing by providing a set of loosely coupled modeling languages that allow the specification of different components of a system. As stated earlier, we address interoperability issues on top of an SOA-based infrastructure.

3. Interoperability standards

In this section, we briefly discuss standards specifications from two domains healthcare and insurance as enablers for our proposed model of cross-domain interoperability. The healthcare industry includes several organizations that develop specifications and standards to support healthcare informatics, information exchange, systems integration, and a wide spectrum of healthcare applications. International and nation-wide standards should be well understood and adopted appropriately to effectively integrate healthcare systems. In the following, two major international and national healthcare standards organizations as well as an insurance standards organization that we adopted in our interoperability project will be discussed briefly.

HL7 is an international community of healthcare experts and information scientists collaborating to create standards for the exchange, management and integration of electronic healthcare information [2]. HL7 RIM (Reference Information Model) defines the body of healthcare information and is a source where the data contents of the HL7 messages are composed from. RIM consists of a number of classes and attributes that are connected through class associations and form a shared view of the information domain that are used by HL7 messages, independent of the message structure.

ACORD (Association for Cooperative Operations Research and Development) [11] is a global insurance association whose mission is to facilitate the development and use of standards for the insurance and related financial services industries. ACORD's standards and services improve efficiency, expand market reach, and supported by a large number of insurance companies, brokers, related financial services organizations, software providers, and industry organizations worldwide.

Canada Health Infoway [3] is an organization that provides specifications for a standard and nationwide healthcare infrastruc-

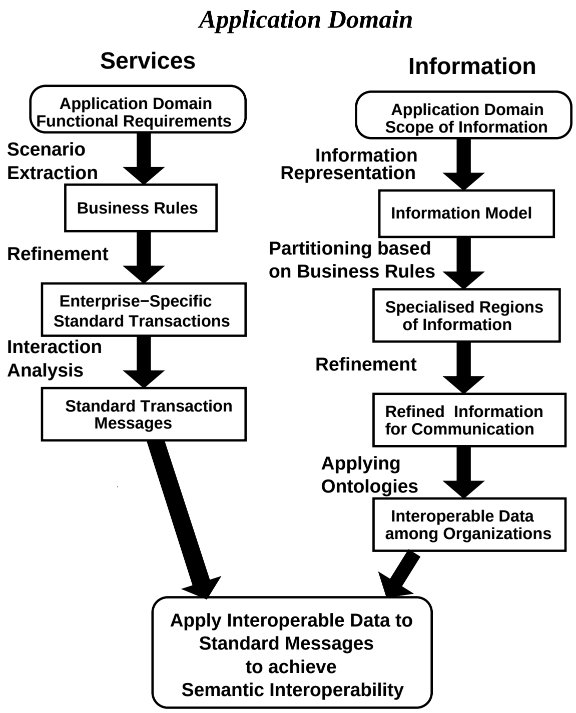


Figure 1. The proposed guidelines for standard-based interoperability provision.

ture. Infoway's mission is to foster and accelerate the development and adoption of an interoperable Electronic Health Record (EHR) system which is compatible with HL7 standards and communications technologies.

Clinical terminology system provides semantic interoperability in an application domain by identifying and accessing information pertaining to the healthcare terms and concepts. SNOMED Clinical Terms (SNOMED CT) [23] is a comprehensive clinical terminology system that provides clinical content and expressiveness for clinical documentation and reporting. It can be used to code, retrieve, and analyze clinical data.

4. Guidelines for standard-based interoperability

Interoperability and standards are almost interchangeably used in the literature for large systems or systems of systems. protocols are used for low-level interoperability provision in domains such as tele-communications and middleware. However, the variety and heterogeneity of the systems at the application level, have contributed to the complexity of interoperability provision in different application domains.

Figure 1 illustrates a generic guideline for standard-based interoperability provision among information systems in a specific domain (or across domains), and the generated steps will be used in an interoperability framework in Section 5. The guideline is generic in the sense that it is not domain specific, hence it can be applied on different domains such as: banking, healthcare, insurance, B2B, and in general any large and heterogeneous system of systems. The guideline consists of two parts: *Services* and *Information* which are processed in separate paths and the results would be merged at the final stage. The "services" branch is responsible for providing a set of standard messages that allow different organizations to communicate and uniquely interpret their data, knowledge, processes, and workflows. The steps for the "services" branch are as follows: i) *Requirement analysis*: functional requirements are determined by the target application domain which represent typical business rules to run an organization in that application domain. ii) *Scenario extraction*: domain specific business rules can be extracted by applying important and common task scenarios that represent generic operations among different organizations in that domain. iii) *Refinement*: refinement of the generic business rules will produce enterprise specific standard transactions which allow different application developers to develop standard communications. iv) *Interaction analysis*: finally, based on the required user/system interactions for each transaction, a set of "messages" are produced that will carry the information to different client and server organizations. Our goal here is to identify the major steps and generated documents; in reality, there could be several iterations and feedbacks between the steps which are not the focus of our discussion.

On the other hand, the application domain's body of information needs to be organized in different ways to be accessible and suitable for communication among organizations with heterogeneous information systems. The overall steps for "information" branch are as follows: i) *Representation*: specialized study groups in the target application domain should agree on the scope of information which consequently must be presented in a well-adopted information representation model such as UML class diagrams or entity-relation diagram. This can be done through information classifiers such as roles, associations, generalizations, and participations. The result would form an "information model" which would represent the scope of information for all organizations within the domain to communicate. ii) *Partitioning*: an application domain has different inter-related specialities; this characteristic suggests to divide the information model into inter-related regions, where each information region has several links to other regions. This step will provide a view-oriented representation of the information model to serve the separation of concern of different specialities and the cross-reference relationship among different expertise. iii) *Refinement*: this step will allow each specialized group to work on the details of information to refine it and produce detailed specifications for the type of information need to be sent for different business activities. iv) *Interpretation*: finally, for some application domains different organizations have their own internal terms and interpretations from business rules and guidelines which make the overall task of interoperability impossible even with compatible technology in place. In this case, a common comprehensive terminology system is required to link identical concepts that are represented differently in organizations. This is a crucial step which provided semantic interoperability

In the above interoperability guideline, the "services" path provides standard message structure for information to be communicated, and the "information" path provides the uniquely interpreted contents for the messages to be exchanged among organizations. These steps are also used in a development process or re-engineering of the legacy systems to achieve interoperability among them.

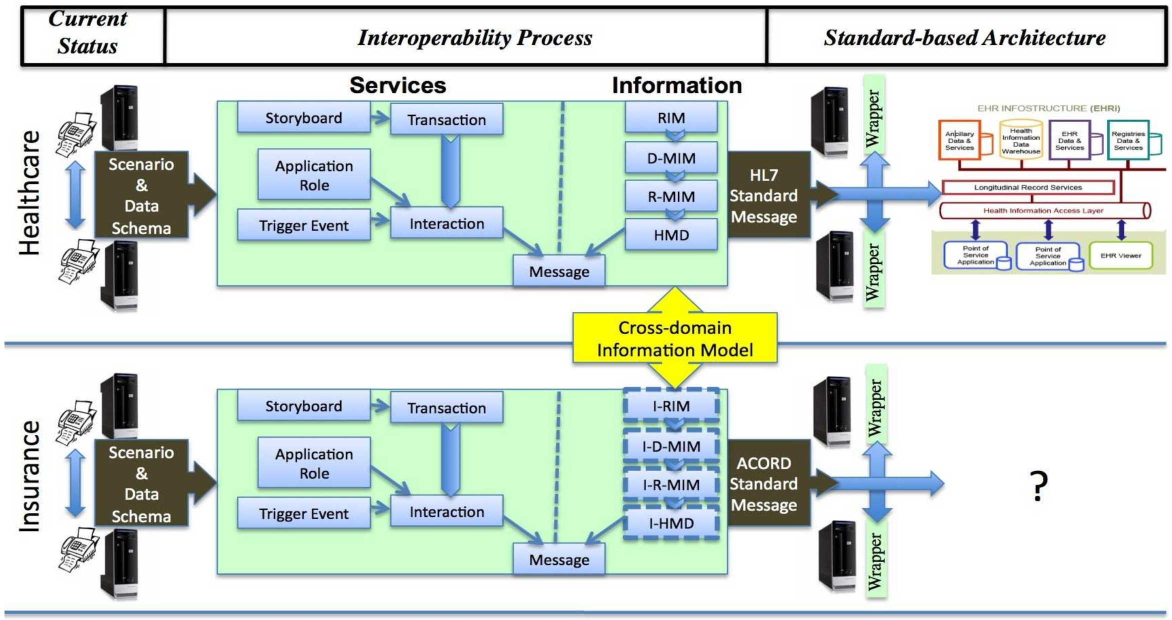


Figure 2. The proposed framework for cross-domain interoperability.

5. Proposed interoperability framework

Figure 2 illustrates the proposed standard-based interoperability framework that incorporates the above steps for the interoperability guidelines to achieve interoperability among systems within a domain or across two domains. In Figure 2, two domains healthcare and insurance along with their "cross-domain information model" are shown, where two legacy healthcare systems (left) are migrated into the HL7-based Canada Health Infoway's standard architecture. For the insurance domain there is no standard-based interoperability architecture (represented by "?"); also the information part of the interoperability process includes dashed-boxes that indicate these steps are partly available in the insurance domain. The proposed framework represents integrating existing legacy systems with new systems as well as developing new standard-based systems. The process for developing new systems is straightforward and will also be required as a part of integrating legacy systems, hence in the followings we only elaborate on integrating legacy systems with a standard-based healthcare infrastructure. The integration is described in three subsections for "services interoperability" and "information interoperability" and "semantic interoperability".

5.1 Service interoperability

In the followings and using Figure 2, different steps for communicating using standard service are discussed.

Existing systems. Most existing legacy healthcare systems communicate their data and results of services through fax machines, telephone calls, and regular mailing system, which are costly, slow, non-reliable, hard to maintain, and cause redundancies in filing information. The goal is to replace traditional communication techniques with state-of-the-art standard-based interoperable systems shown in Figure 2 (right).

Interoperability process. This part represents the steps required to migrate the data and services of the legacy systems into standard-based and interoperable systems. The steps for the interoperability process are as follows.

Storyboard is a short story used to define the business requirements via a narrative of relevant events defined using interaction diagrams or use cases.

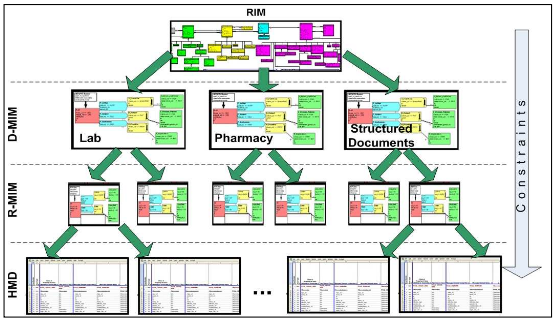
Transaction is a single use-case within the storyboard that represents a particular functionality of the system that is performed by interacting with the system. A storyboard can generate several transactions.

Interaction is a single, one-way information flow that supports a communication requirement expressed in a transaction.

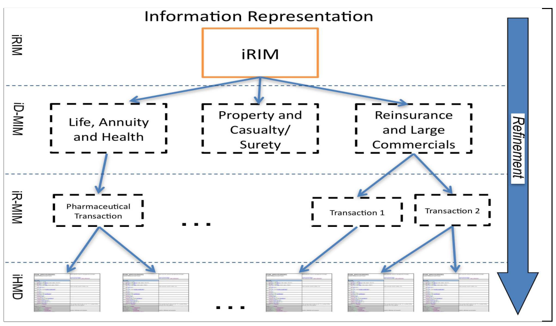
Trigger event is a UML term for an event, where an application uses an event to initiate an interaction in order to transfer information to another application.

Application role represents the responsibility of an application during the interaction with another application that is initiated by a trigger-event.

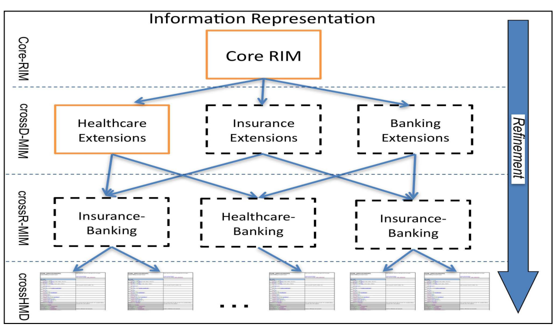
Standard-based architecture. This part represents the integration of the transformed messages of the legacy system (as domain-specific standard messages) with a standard architecture within a domain. Such an architecture exists in healthcare domain. Infoway's *Infostructure* takes advantage of standard services of the Infoway architecture and communication using service oriented architecture and many other standard services, as specified by the Infoway's EHRi blueprint [3]. The question mark in the insurance part (lower row) demonstrates that there is no standard architecture such as Infoway in insurance domain. In the following subsection, the details of the data interoperability process is described, where the resulting XML formatted data will be fed to the



(a) HL7 v3 information refinement process.



(b) Information model refinement for insurance.



(c) Information model refinement for cross−domain interoperability.

Figure 3. The refinement process steps for cross-domain interoperability provision.

domain-specific standard architecture that are specified by the interoperability process of Figure 2. The proposed process can also be used to achieve cross-domain interoperability using an information model which is inspired from both domains' information models.

5.2 Information interoperability

The proposed framework in Figure 2 consists of three information models for healthcare, insurance, and their cross domain, where the healthcare domain has a comprehensive model HL7, the insurance domain has a partly defined information model, and the cross-domain information model will be built upon the existing two related domains healthcare and insurance according to the guideline of Subsection 4. In the following, these three information models are described.

HL7 information model

HL7 methodology uses specific rules to refine its information model consisting of RIM, HL7-specified Vocabulary Domains, and version 3 Data Type Specification to develop the information structures that specify Message Types and equivalent structures in HL7 v3. The strategy for development of v3 messages and their related information structures is based upon the consistent application of constraints to a pair of base specifications, i.e., HL7 RIM and HL7 Vocabulary Domains, and upon the extension of those specifications to create representations constrained to address a specific healthcare requirement. Figure 3(a) shows the refinement process specified in the HL7 methodology, where the different parts are defined below.

- *Domain Message Information Model* (D-MIM) is a subset of the RIM that includes a fully expanded set of class clones, attributes and relationships that are used to create messages for any particular domain.
- *Refined Message Information Model* (R-MIM) is used to express the information content for one or more messages within a domain. Each R-MIM is a subset of the D-MIM and contains only those classes, attributes and associations required to compose the set of messages.
- *Hierarchical Message Description* (HMD) is a tabular representation of the sequence of elements (i.e., classes, attributes and associations) represented in an R-MIM. Each HMD produces a single base message template from which the specific message types are drawn.
- *Message Type* is represented as a unique set of constraints in the form of a table or spreadsheet, and identifies an HL7 v3 message.

Insurance information model

As indicated in Figure 3(b), we propose to apply the same steps for information refinement in healthcare systems (Figure 3(a)) to other application domains possessing large systems. For "insurance domain" there are three different specification documents namely "*Life, Annuity and Health Insurance Specifications*", "*Property and Casualty/Surety*", and "*Reinsurance and Large Commercial*". We propose to adopt an iRIM ("i" stands for "insurance") that represents the common set of classes, attributes and relationships between classes among all the existing sub-domains in insurance. The iRIM is derived from HL7-RIM and consists of classes that are not specific to healthcare, including the six RIM foundation classes: *Entity, Act, ActRelationship, Participation, Role*, and *RoleLink*. Any other class which is needed to be added to represent insurance information should be a specialization of these six foundation classes. Other general RIM classes which are present in this information model include: *WorkingList*, *Procedure*, and *Exposure*, since they lack any domain-specific information. For each set of scenarios to perform information exchange, there exists an iDMIM which is a clone of classes of iRIM that are constrained to the requirements of that set of scenarios. Further refinement is performed to generate iRMIM for each transaction of a scenario and iHMDs for their required interactions. The above approach to build insurance information model would also resolve the ACORD's existing inconsistency in their deliverables and components across the three standards sub-domains (L&A, PCS, and RLC), however we propose a consistent and shared information model among all sub-domains. As stated by ACORD, this inconsistency limits the insurance industry from proper usage of ACORD standards across an enterprise and in supporting common needs [12].

Cross-domain information model

In order to achieve cross-domain interoperability, we propose to use the same process of refinement as in HL7 v3 information model [9] to build a consistent information model between different domains. We adopt a Core-RIM that represents the common set of classes, attributes and class-relationships between two domains healthcare and insurance. The Core-RIM is derived from HL7-RIM and consists of classes that are not specific to healthcare. For each set of scenarios to perform information exchange between two domains, there exist a cross-DMIM which is a clone of classes of Core-RIM that are constrained to the requirements of that set of scenarios. Further refinement is performed to generate cross-RMIM for each transaction of a scenario and cross-HMDs for their required interactions.

5.3 Semantic interoperability

To achieve common understanding of message contents among stakeholders of a domain, each domain requires a terminology system which clearly defines and relates different concepts in that application domain. This requirement (i.e., having a shared terminology system) is more crucial when systems from different domains are communicating through messages. Each concept within HL7 RIM is bound to two terms, as: i) *labeling* which refers to a concept's attribute; and ii) *value* which refers to the attribute value. Generally a LOINC [8] term is used as a label and a SNOMED term [23] is used as a value. For example for the height of a patient, Infoway selects body height - measured with code 3137-7 from LOINC as a label and Body height measure (observable entity) with code 50373000 from SNOMED as a value. Both in SNOMED and LOINC, a unique concept with a unique code might be found under different branches of the SNOMED/LOINC's concept tree. In this case the judgement of an expert is required to decide on the most relevant concept to the local term. In ACORD, it is much simpler to deal with terminologies. There is a section named *Lookups* in each sub-domain's document which contains the specific terms for the specific domain in insurance. ACORD's approach is not as strong as HL7 v3 approach since the terminology system is not shared and consistent among sub-domains and it adds up to heterogeneity of the standard.

We propose to use a shared terminology system which possesses the same architectural style as SNOMED CT terminology system. It consists of concepts that are logically defined by relationship to one or more other concepts. Formal rules for *post-coordinated* expressions are used to make this terminology system precise in terms of relationships between concepts. Any concept can be refined using this formal rule. Concepts are represented in a *compositional grammar* [23]. Having a shared terminology system among all sub-domains is necessary to have consistency inside the specific domain. In this case we have both domains' terminology systems in the same architectural style, we can integrate both terminology systems to apply ontology to achieve cross-domain interoperability between healthcare and insurance.

In our first case study to exchange pharmaceutical information across two different systems in different domains, we accepted SNOMED CT vocabulary system architecture and added concepts that are needed to be exchanged to the whole terminology system. We added healthcare specific terms extracted from CeRx PORX-MT030040CA and COCT-MT220100CA using a temporary coding system for the limited number of concepts within the terminology system. To expand it to include insurance specific concepts, we also added concepts that are used for exchanging pharmaceutical information in ACORD *Life and Annuity Standards Licensing and Appointments Implementation guide V2.1* Lookup section [7].

6. Case Study

In order to assess our framework, we provide a real world case study. This case study applies the proposed guidelines in Section 4 to achieve a standard way to explore healthcare databases by an insurance party. The output of this case study is a set of messages which are HL7 v3 compatible.

6.1 Pharmaceutical interoperability between insurance and healthcare

According to Section 5.2, we adopted HL7 v3 information refinement process. As stated by ACORD standard documents, the life insurance industry is quickly moving to explore other data sources in their underwriting and decision process. We have reviewed the following documents for this case study: *ACORD Life, Annuity and Health standard documents* [7] and CeRx (Canadian Electronic Drug) messaging documents specifically COCT-MT220100CA -Orderable Medication and CeRx PORX-MT030040CA-Drug Prescription Summary [4]. The step-by-step description of the application of the proposed guideline in Section 4 is as follows.

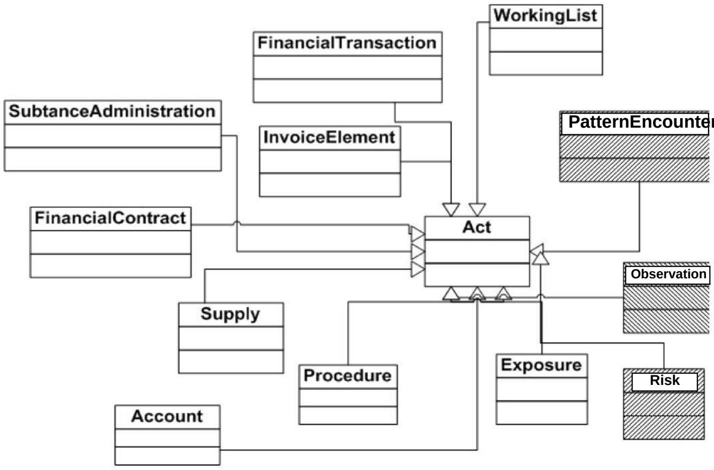
i) Scenario definition: the scenario is: "*to explore external pharmaceutical databases by an insurance application*" which provides inter-domain interoperability with ACORD standard.

ii) Refinement: different transactions are explored, however the one that is selected for this case study is *Pharmaceutical Information Transmittal* tc=1601 from ACORD that directly involves exchanging information with a pharmacy or a healthcare system. This transaction includes two interactions *TXLifeRequest Data Stream Requirements* and *TXLifeResponse Data Stream Requirements* [7].

iii) Interaction analysis: the selected interaction is *TXLifeRequest Data Stream Requirements* which is the response to the request to receive *Drug Prescription Summary* from a pharmacy or healthcare system.

In the following, the application of the *Information* representation and refinement of the proposed guideline is presented.

iv) Information representation: the required information for this transaction is collected and its class diagram is generated with proper attributes and relationships. The information to be exchanged between healthcare and insurance parties were extracted from the CeRx documents on *Pharmacy Drug Summary* and *Life, Annuity and Health* documents in insurance. We first selected the intersection of all data that are shared between these two domains and then we added the data that are required by one of the parties (either healthcare or insurance). We mapped the class diagram generated in the previous step to the existing Core-RIM. The white-colored classes within Figure 4 illustrate Core-RIM classes and the gray-colored classes are the extended classes. Figure 4(a) illustrates the comparison between Core-RIM Acts Subject Area with the very basic classes that we selected to be the Core-RIM and the specific



(a)

```xml
<includeNotesIndicator>
   <value value="true"/>
</includeNotesIndicator>
<includePendingChangesIndicator>
   <value value="true"/>
</includePendingChangesIndicator>
<mostRecentDispenseForEachRxIndicator>
   <value value="true"/>
</mostRecentDispenseForEachRxIndicator>
<patientBirthDate>
   <value value="19650726"/>
</patientBirthDate>
<patientGender>
   <value code="F" displayName=
   "female" codeSystem="3">
</patientGender>
<patientID>
   <value extension="444112345"
    assigningAuthorityName="Alberta,
    Canada Unique Lifetime Identifier (ULI)"/>
</patientID>
<patientName>
   <value use="L">
      <prefix>Mrs.</prefix>
      <given>Ana</given>
      <given qualifier="IN">W</given>
      <family>Nuclear</family>
   </value>
</patientName>
  </parameterList>
</queryByParameter>
```

(c)

ACORD Attribute	ACORD Type	ACORD Document	Name of Message field	Cross-Message Standard	Type	Derived from Document
PrescriptionDosageUnit	TypeCode	Transactions-Life, Annuity and Health	Rendered Dosage Indtruction	component1.administrationInstructions.text	ST	CeRx-PORX_MT030040CA- Drug Prescription Summary
PrescriptionDosageStrength	Integer	Transactions-Life, Annuity and Health	Rendered Dosage Indtruction	component1.administrationInstructions.text	ST	CeRx-PORX_MT030040CA- Drug Prescription Summary
PrescriptionCode	String	Transactions-Life, Annuity and Health	Drug Code	player.code	CV	CeRx-COCT_MT220100CA-Orderable Medication

(b)

Figure 4. (a) Extended RIM from the Core-RIM. (b) Mapping between ACORD message fields and cross-domain message fields. (c) One message sample: Response to Prescription Summary Query.

extensions for the whole scenario of receiving pharmaceutical information by an insurance party. The Observation and PatientEncounter classes (already in HL7 v3 RIM) are extended for healthcare requirements and the class Risk is for insurance side.

v) Partitioning based on business rules: following the refinement process, we select the classes from the above extended Core-RIM that correspond to the scenario and apply cardinality, vocabulary, and type constraints. The produced Cross-DMIM include the class from the Acts Subject Area: *PatientEncounter, Observation, Risk, Exposure, Supply*, and *SubstanceAdministration* in Figure 4(a).

vi) Refinement: for transaction code tc=1601 in LAH ACORD standards we group the classes into Pharmaceutical Information Transmittal R-MIM and refine the message information for each of the interactions. Using a tabular representation of the serialized data, a spreadsheet form serialized data for each of the messages is generated. The output of this step is two Excel files, one for the query interaction and one for the response. Using XML technology for message passing and XMLSpy tool, we generated the schemas for the request and response messages; one instance is shown in Figure 4(c). These messages are HL7 v3 compatible and syntactically and semantically are interoperable with HL7 v3 compliant healthcare systems.

The following step is required to make the generated messages work properly with existing insurance standard, ACORD.

vii) Mapping: to allow these messages work properly with ACORD standard, a mapping between these message fields and the ACORD message fields for tc=1601 is generated and presented in Figure 4(b).

7. Discussion and Conclusion

The variety and heterogeneity of legacy systems in an application domain is a source of complexity for achieving interoperability among those systems. In this path, traditional healthcare information systems require to interoperate with systems in collaborating domains. Standards organizations such as HL7 and Canada Health Infoway have provided the ground for these systems to manage domain information in a way that different participants can integrate their proprietary legacy information systems to a nation-wide network and use widely approved services to communicate with a large group of clients. The same standardization philosophy can be provided for different purposes and domains, such as: security and defence (army), business and trading (e-business, e-commerce), organization systems (e-government), financial systems (banking and trading). These systems can be categorized as very large systems or systems of systems. In real-world cases, systems from different application domains frequently require to communicate messages, concepts, and cases across different domains (such as healthcare and insurance, army and air-force, reservation companies and financial sectors). The key aspects in such cross-domain interoperability and communication are: consensused and standard messaging technique, information representation, and most importantly a common terminology system that binds similar concepts in different organizations. In this respect, the new standards in healthcare domain have provided healthcare domain with advanced techniques that allow data and service identification, as well as interoperability to be performed in a very systematic manner. This allows the common integration task "data and service migration" to be accomplished with a little help from the healthcare expertise. This is a major advancement in smoothing the task on interoperation of legacy systems. In this paper, we proposed two directions in achieving such goal; the first is a common and standard based development process that organizes the body of knowledge within application domain and also produces a knowledge base of standard messages and recipes on how to use them; and the second is to use the same philosophy but across the domains not in the same domain.

A major goal of the case study in Section 6 is to offer a pilot project on integration of healthcare and insurance systems according to the leading-edge standards. It is ideal to provide general development steps for the proposed framework such that the procedures and results can be reused by other developers in similar projects. In order to achieve this generality, we decided to use available industrial products and show how they can be adopted in major projects while complying with healthcare standards. This decision is necessary to prevent the proprietary implementations and vendor/application dependency.

8. References

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