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Toward the Interoperability of HL7 v3 and SNOMED CT: A Case Study Modeling Mobile Clinical Treatment

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Abstract

Semantic interoperability in healthcare can be achieved by a tighter coupling of terminology and HL7 message models. In this paper, we highlight the difficulty of achieving this goal, but show how it can become attainable by basing HL7 message models on SNOMED CT concepts and relationships. We then demonstrate how this methodology has been applied to a set of clinical observations for use in the ePOC project, and discuss our findings.

Keywords:
SNOMED, HL7, interoperability, terminology

Introduction

One of the biggest obstructions to communication in healthcare occurs when there are multiple ways of describing a single concept. Using a standard terminology of clinical concepts is the first step to unambiguous information exchange. If the primary clinical data entered into a system is structured using a standard expressive vocabulary, this data can then be used for secondary purposes in later stages of patient care, such as search of and selective presentation of data, decision support, and statistical evaluation [1].

In the course of constructing the Kaiser-Permanente Convergent Medical Terminology (CMT), Dolin, et al have reviewed three major terminologies and described their weak points [2]. The terminologies they employ are SNOMED CT, laboratory LOINC, and First DataBank drug terminology. In particular, with respect to SNOMED CT they conjecture that standardizing certain subsets of concepts for use in HL7 messages would greatly enhance interoperability, but first some research would have to be conducted into where the HL7 RIM and SNOMED CT overlap, and some formal guidelines be developed.

In [3] a proposal and possible solution to ambiguous communication involving basing HL7 message models on SNOMED CT concepts and relationships was discussed. Further to this, SNOMED CT concepts corresponding to a set of clinical observations have been mapped to HL7 message models for use in the ePOC (electronic Point of Care) project, and as a proof-of-concept.

Methods

HL7 Version 3

Version 2 of the HL7 standard is widely implemented; however it has been increasingly difficult to support health information interoperability in today’s rich computing environment using this methodology. Version 3 of the HL7 standard incorporates a new paradigm for information representation and messaging in comparison to HL7 version 2 in terms of a new information model and intrinsic extensibility [5]. The Reference Information Model (RIM) is the cornerstone of the HL7 Version 3 development process. The RIM is an object model in the form of a large UML-like representation of clinical data and is a powerful abstract model of healthcare [1, 5, 6].

The ePOC project is a multi-phase, iterative R&D project with a research focus involving the development of a prototype Personal Digital Assistant (PDA) based point-of-care information delivery system for The Ambulatory Care Team (TACT), Northern Illawarra, Australia [4]. TACT has a requirement to enter data at the point-of-care about a patient condition and the clinical activities carried out during the ambulatory visit. In its implementation, ePOC addresses the difficulties of federating disparate data, HL7 messaging, implementation of clinical terminology, and the limitations of the mobile platform within a practical community clinical health service environment.

The terminology we are concerned with in the ePOC project is SNOMED CT, as we are focusing on clinical data. Laboratory and drug codes are outside the scope of the ePOC project.

Our preliminary findings from mapping clinical observations data required by TACT to HL7 based on SNOMED CT concepts and their relationships are discussed in the following sections.
SNOMED CT

SNOMED CT is a universal health care terminology, the aim of which is to make health care knowledge usable and accessible wherever and whenever needed [7]. The SNOMED CT core terminology provides a common language that enables a consistent way of capturing, sharing and aggregating health data across specialties and sites of care. SNOMED CT contains more than 344,000 active concepts: the most comprehensive clinical vocabulary available in any language, covering most aspects of clinical medicine [8].

Clinical observations

Eight clinical observations are made by TACT clinical staff every time they visit a patient. These clinical observations were chosen as the starting point in the ePOC project for sending messages containing clinical information from the central database to the PDA and vice versa.

The eight clinical observations are:

- Temperature
- Pulse
- Respiration
- Blood Pressure
- Oxygen Saturation (O₂Sat)
- Weight
- Blood Sugar Level
- Urinalysis

Clinical observations required by TACT have corresponding SNOMED CT codes and data structures for each of these observations were ascertained. From this point, HL7 messages were modeled based on the relationships between the chosen SNOMED CT concepts.

SNOMED-CT concepts and relationships

According to Markwell [9], statements about clinical findings can be divided into two categories: those in which there are two clearly distinct facets (example 1) and those which are often captured as a single "nominalized" expression (example 2):

- Pulse rate = 82 beats/minute (1)
- Has a fracture of his right femur (2)

Looking at (1), the two facets are separated by the equal sign (=); the first being the property which was observed (Pulse rate) and the second the result of the observation (82 beats/minute).

Clinical findings in the second category (2) raise a plethora of issues in where, or even whether, to split the different concepts represented by the statement. Some of the choices are to split them as shown in examples 3 and 4:

- Property = right femur, finding = fracture (3)
- Omit property, finding = fracture of right femur (4)

In (3), the clinical finding has been split into two-facets in an attempt to model the simpler type of finding. In (4), the concepts represented in the clinical finding have not been split at all. It can be seen where problems may arise when different people use different methods of representation, especially in situations where there are many concepts combined to create one finding, hence causing many more forms of representation, e.g., “the patient has a family history of myocardial infarction”.

All the clinical observations in our set of eight are of the two-faceted form (except urinalysis which is made up of many two-faceted observations). With this in mind, it was decided not to use SNOMED CT concepts from the Clinical Finding hierarchy as the description codes for the property to be recorded, instead it was decided that it is more effective to represent a clinical finding in this context as a SNOMED CT concept from the Observable Entity hierarchy, plus a value. This is in line with the two-faceted model, the first facet being the Observable Entity and the second facet its observed value.

Concepts from the Clinical Finding hierarchy are then used in decision support to describe inferred concepts taken from the recorded observation codes and their associated value. For example, if the value recorded for a patient’s blood pressure is above a certain point, the concept of high blood pressure from the Clinical Finding hierarchy will also be recorded against the patient. We will not go into much detail about decision support, as discussion of the inferred finding aspect of our model is not the subject of this paper.

Figure 1 shows a subset of the SNOMED CT Observable Entity hierarchy used in our messages. The top level concept in this diagram is vital signs. Only four of the eight clinical observations required by TACT have corresponding concepts which are subtypes of the vital signs concept, the other concepts (corresponding to O₂Sat, Weight, Blood Sugar Level and Urinalysis) are at the same level in the hierarchy as vital signs, and are all subtypes of observable entity. The "vital signs" subset is used as an example here for simplicity and readability. The circles in the diagram represent the concepts and the arrows depict a subtype relationship, the opposite direction being the IsA relationship.

The procedures followed to make these observations have corresponding concepts under the SNOMED CT Procedures hierarchy, with near-identical relationships. Figure 2 shows a subset of the Procedure hierarchy used in our messages.

HL7 messages based on SNOMED CT structures

One of the findings from Dolin, et al. [2] in the CMT project is that a tighter coupling of SNOMED CT and HL7 would greatly enhance interoperability between healthcare systems. They argue that different implementations of HL7 could use different code sets and coding schemes. This problem can start to be solved by doing away with the HL7 tables and using SNOMED CT code subsets exclusively for all code-type fields, thus setting a standard coding scheme for use throughout the model. The two exceptions to this rule are the HL7 classCode and moodCode fields, although the allowable codes for these two fields are already defined by standard, non-extensible code sets within HL7, so this will not create a problem.
The eight clinical observations are represented in the HL7 model by instances of the Observation specialization of the Act class. Issues involving the use of terminology in the Observation.code and Observation.value fields have caused much discussion and debate [9], as discussed in the previous section. However, in the case of the two-faceted clinical finding, the representation is straightforward. In this case, the Observation.code field contains the SNOMED CT code for the observation (or property), and the Observation.value field contains the measured value (or finding) for the observation.

The procedures shown in Figure 2 are put into the Observation.methodCode field to further enrich the model, by capturing both of the SNOMED CT hierarchies within the one HL7 Act “hierarchy”.

The inferred findings discussed briefly in the previous section are put into the observationInterpretation field, but no relationships can be inferred between the observations based on this field.

Future SNOMED CT to HL7 mapping will also include the targetSiteCode field of the HL7 Observation class, in which the body site will be represented by a SNOMED CT Body Structure code.

**SNOMED CT hierarchy represented in HL7**

The SNOMED CT IsA relationship can be considered in two ways when representing it in the information model for clinical observations.

The first is that the parent (destination of the IsA relationship) is a collector (list) of entries of subtype clinical observations. This SNOMED CT concept hierarchy is preserved by the code field in the Observations and the HL7 component and componentOfActRelationships. For example, in Figure 1, blood pressure is a subtype of vital signs and can be said to have the relationship IsA with vital signs. The SNOMED CT IsA relationship corresponds to a HL7 componentOf relationship, for this field.

Likewise, the relationships between the Procedure concepts for each Observation in the methodCode field are also preserved. For example, in Figure 2, blood pressure taking is a subtype of taking patient vital signs and can be said to have the relationship IsA with taking patient vital signs. Thus, the HL7 componentOf relationship also represents the IsA relationship for this field.

The second way of considering the SNOMED CT IsA relationship is to think of the parent as a generalization of the subtypes and thus defining a commonly supported pattern of supported specializations. The specializations constrain the allowed use of attributes, and allowed value domains/sets for attributes. This includes coded attributes in the specialization classes being restricted to valid SNOMED CT hierarchies. This has the effect of describing a HL7 v3 model hierarchy of HL7 templates with a messaging model being used as the base such as HL7 Care Provision Domain [10] messaging or Clinical Document Architecture [11].

Figure 3 shows an excerpt of the HL7 model based on the vital signs subset, along with the hierarchies shown in Figures 1 and 2, with arrows showing where the codes for these concepts fit into the HL7 model.

This message model has been implemented in the ePOC project for use in communication between the PDA and the central database. Field trials of ePOC are scheduled for May, in which TACT clinical staff will employ the use of the PDA with the ePOC application in their daily home visits.

**Conclusions**

By basing HL7 message structures on SNOMED CT relationships a tighter coupling between data model and terminology can be created. The preliminary application of this model for simple observation data has shown that it is possible and applicable. Careful thought is being put into applying the model for more complicated data, i.e. the “nominalized” type of data shown in example (2).

The work shown here is just the beginning of mapping SNOMED CT relationships to HL7 message structures. We are moving toward a semi-automated system for creating HL7 messages on the fly, based on SNOMED-CT concepts selected by clinicians at the point-of-care. We say
“semi-automated” because we would like the messages to be generated with as little human input as possible, but realize that achieving full automation of this process is highly unlikely. An example rule based on the clinical observation data presented here is that a SNOMED CT Observable Entity must be represented in HL7 as an Observation specialization of the Act class, with the SNOMED CT concept ID populating the Observation.code field.

Future directions of research will focus on furthering semantic interoperability between Healthcare systems using what we see as the best technology in the area.

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