Computer-Facilitated Collaboration: Experiences Building SNOMED-RT

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Collaborative development involving both individuals and groups is often less efficient than independent development because of communication overhead and integration costs. Despite the decreased development efficiency, collaborations promise more general-purpose products because of the opportunity for integration, with negotiation and reconciliation of diverse perspectives. Collaborations are also perhaps less costly when considered in contexts where there is significant duplication of effort. Computer-facilitated collaboration can reduce the communication and integration burden such that the increased effort required to manage a successful collaboration focuses primarily on the development of shared conceptual model among the developers by requiring that the work product be independently reproducible. This reproducibility requirement incorporates formal quality assurance processes into the development process. In this paper, we describe our initial experiences developing SNOMED-RT using such a computer-facilitated collaborative process. We quantify the extra costs incurred to achieve consistency in our efforts and reproducibility of our results.

INTRODUCTION

To measure quality of medical care, we collect clinical data and analyze it. The terminology used to represent this data must be understood by the providers who encode the data, and the data must be collected by a process that is reproducible across providers, institutions, and geographic regions. Without this reproducibility, any analysis of the collected data is suspect.

As a first step towards ensuring that the underlying terminology used for data collection is understandable by providers who can then reproducibly encode patient information using that terminology, we have developed a process for SNOMED-RT development that incorporates understandability and reproducibility validation. This process is designed to be scalable as the size of the terminology grows and as the size of the collaborative resources dedicated to SNOMED-RT development grows.

The foundations of SNOMED-RT and the specifics of the computer-based Galapagos tools that enable distributed collaboration have been previously described [1-3]. Here we describe our experiences applying these tools to SNOMED-RT development, and we also describe an expanded process supported by these tools that incorporates quality assurance by enforcing reproducibility of individual work. We believe the computer-facilitation—and computational-enforcement of reproducibility—differentiates our methodology from other terminology collaborations. Our processes could readily fit within other collaborative frameworks including as the Unified Medical Language System [4] and the Read Codes [5].

REPRODUCIBLE COLLABORATIVE PROCESS

Effective collaborations require more than simple coordination of activities that seek to integrate the works of disparate groups. Some have argued that “true” collaborations require such singularity of execution that it seems as if the works came from a single mind [6]. We believe that a first metric for singularity of execution is to demonstrate that when independent collaborators apply the same process to the same task, they generate the same result. A first step in most collaborations is to agree on the objectives and general principles that guide collaborative activity. Once developed, these principles become the foundation for processes which will allow the generation of shared work product. Finally, computer-based tools can help enforce the process, increasing the probability that the work product is reproducible. We discuss our experience with these three steps in the next sections on modeling principles, modeling process, and modeling tools.

Modeling Principles

SNOMED-RT is a reference terminology for clinical data intended to support retrieval and analysis of data relating to the causes of disease, the treatment of patients, and the outcomes of the overall healthcare process [3]. Modelers realize these intentions in the
diagnoses section of SNOMED-RT by applying pathophysiology and organ-system oriented modeling principles such that each diagnostic term will have appropriate morphologic, anatomic, and etiologic relationships explicitly defined.

**Modeling Process**

Modelers independently enhance the terminology in ways they believe support the high-level objectives of SNOMED-RT. These terminology enhancements are then loaded into a Galapagos configuration-management system that stores the history of all work products, and identifies when one individual’s work conflicts with the work of another [2].

When conflicting work is identified, conflict reports are generated, and reviewed by the modelers. This review includes a discussion for the reasons behind the conflict, and development and documentation of new or revised guidelines regarding how to model individual terms. These guidelines are maintained in the Modeler’s Style Guide—a living document that embodies the modeling principles inherent in SNOMED-RT development.

**Modeling Tools**

Each modeler has individual access to a common set of reference materials. These reference materials include:

- Stedman’s Electronic Dictionary.
- Dorland’s Illustrated Medical Dictionary (not electronically available).
- MDConsult (http://www.mdconsult.com), an online service which provides electronic access to over 30 up-to-date medical textbooks.
- The Modeler’s Style Guide.

Because all the modelers have access to the same authoritative reference material—and the modeling process requires them to explicitly describe their assumptions in the Modeler’s Style Guide as part of the conflict resolution process—we hope to optimize the understandability and reproducibility of the development process and the developed product.

The process for revising the Style Guide is illustrated in Figure 1. As shown there, a domain specific (chapter specific) issue is usually documented by individual modelers working together in the same domain, while general modeling issues are usually documented after group consensus and review by representatives of SNOMED. When consensus is not reached, the group depends on arbitration by the SNOMED Scientific Director on behalf of the SNOMED Editorial Board to provide consistent direction.

Because the modelers are geographically dispersed, communication tools are vital to foster adequate collaboration. Electronic mail, a modelers’ listserver, teleconferences, and quarterly modelers’ summits provide forums for individual modelers to raise issues of interest to the entire group. These collaborative venues offer opportunities for encouraging the entire group to arrive at consensus on issues that aren’t yet resolved in the Style Guide.

The conflict-resolution tool the modelers use to review and resolve conflicts is called Rhabida (one of the Galapagos islands) [2], and is presented in Figure 2. This Java-based GUI allows modelers to view two or more proposed definitions for a concept. In addition, the modeler may directly select which elements of the proposed definition (e.g. defining parents and roles, and non-defining attributes) are correct and will be retained, as well as determining which elements are incorrect and will be edited out.

As seen in Figure 2, the differing models or proposed definitions being offered are presented across the screen in the lower panel. The upper left panel contains the maximum common definition—the portion of the conflicting definitions that all participants agree to. The components of the maximum common definition are displayed in white. The maximum common definition is the starting point for resolving the conflicting definitions of the concept being viewed, but modelers may remove any element deemed incorrect. Other proposed parents and defining roles that were not present in all proposed models are viewed in the upper right panel.
These elements are color-coded so a modeler can quickly identify their source of origin. These elements may be added to the maximum common definition on the left by double-clicking on them. Rhabida also allows the user to append nondefining comments to the definition. Once the modeler selects the “commit” button, then this “resolved definition” is written to a file that is subsequently imported into the configuration management database.

The tool set used to resolve modeling conflicts is constantly growing and evolving, but at a minimum includes the reference material (both internal and external), communications tools, and the Galapagos terminology modeling tools.

**Term by Term Process**

Each modeler uses the same sequential process for resolving individual term conflicts in the Rhabida environment. As illustrated in Figure 3, this process begins with looking up the term in a dictionary or an on-line textbook. If neither of these sources helps the modeler understand the meaning of the concept, it may sometimes be inferred by looking at synonyms in SNOMED or by determining the position in the SNOMED hierarchy.

Once the modeler has sufficient understanding of the term, Rhabida may then be used to assign all acceptable parents and defining roles to the concept being modeled and to delete inappropriate elements.

Once this conflict-resolution process is complete, the new definition that is built in the upper left panel of Rhabida is the “resolved state.” This resolved definition is considered to have greater authority than any of the individual proposed models of which it is composed.

Each term being processed is reviewed independently by two modelers, (although a few initial concepts may be reviewed by modelers working together to have a chance to discuss issues that may arise when they begin to work independently). This independent review validates the reproducibility of the semantics assigned to each term. For each term conflict, both modelers review the conflict and submit their “resolved conflict” entries into the Galapagos configuration management system, and if the resolutions are not equivalent, the concept is sent back for re-review. The algorithms for determining conflicts are described in [2].
RESULTS

We applied the processes documented above to 19,223 of the terms in the SNOMED 3.3 D-axis for which there were 2 or more proposed definitions. The 3 sources of the potentially conflicting definitions were definitions generated by lexical/hierarchical algorithms applied to SNOMED 3.3, the cross references from SNOMED 3.3, and those developed by CMT modelers using editing tools. Our results are summarized in Table 1.

The data presented here demonstrate that our processes enable us to achieve a common definition for every term, based on the agreement of at least two modelers. Furthermore, a common definition was achieved for 84% of the terms through independent modeling, while the remaining 16% of terms were resolved through joint discussion. In general, 4 or 5 rounds of review were necessary for this convergence given the goal of reviewing most terms independently to promote reproducibility of definitions.

The “cost” of the extra effort of this iterative approach is presented as the cost relative to that of a single review of the same terms. This is calculated by totaling the total number of term reviews necessary to finish a chapter and multiplying by 2, then dividing by the number of terms in the chapter. Thus our dual review process, with heavy emphasis on independent review, appears to have a relative cost of at least 3.5 times what it would cost to singly review the same terms.

DISCUSSION

Our experiences suggest that our 13 modelers from 13 different geographic locations can reproducibly apply the principles documented in the Style Guide to resolve the majority of conflicting term definitions, even upon independent review. For the remaining conflicts not covered by general principles, it has been our experience that a few common “themes” emerge. By agreeing to and documenting our common approach to these issues, we can continue to reproducibly model most of the remaining terms.

There are other approaches we could have employed to build SNOMED-RT from the 3 types of proposed definitions.

A single authoritative reviewer could have reviewed all terms once to minimize the cost of the terminology modeling. This option would presumably provide semantic definitions that would risk being the least understandable to a non-modeler and the least reproducible by subsequent modelers. Our experiences with incomplete convergence after a single round of dual review using the same Style Guide principles appear to support this assertion.

We considered performing a dual simultaneous review of each and every term, but this was logistically impossible for our modelers given geographic spread and other clinical responsibilities. In addition, there was concern that dual review would make reviewers less likely to recognize and document common “themes” around areas of potential disagreement. If this assumption is correct, then future reproducibility and usability could be compromised by this approach.

In the future, we may consider a combination of the above approaches by one or more rounds of dual review, followed by single reviews by more authoritative sources trained in documentation. The optimal approach is not clear at this point, as we feel that efforts to increase understandability and reproducibility of a semantically based terminology are likely to be limited by issues of practicality and cost. We have articulated an approach that we feel strikes a reasonable balance between our definition of quality and cost given our current resources.
CONCLUSION

We have shown that it is possible to use a basic set of modeling principles and computer based comparison tools to allow independent terminology modeling efforts to converge on a common view of medical terminology. We believe that the rapid convergence pattern observed when two independent modelers review the same sets of terms demonstrates the reproducibility of this approach. Similarly, we believe that by continually refining our approach to challenging modeling issues on the basis of our shared experiences and group consensus, we can develop a terminology that is comprehensible and will support the goals of SNOMED-RT.

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REFERENCES


