Collaborative Encoding of Asbru Clinical Protocols

Marco Rospocher[1], Claudio Eccher[1], Chiara Ghidini[1], Rakebul Hasan[1], Andreas Seyfang[3], Antonella Ferro[2], and Silvia Miksch[3]

[1] Fondazione Bruno Kessler, Trento, Italy
[2] Medical Oncology, S. Chiara Hospital, Trento, Italy
[3] Vienna University of Technology, Austria

Abstract. Encoding guidelines and treatment protocols in formal and computer-executable form is not a trivial task and requires the collaboration between clinicians and knowledge engineers. In this paper, we describe CliP-MoKi, a Semantic Media Wiki (SMW)-based tool for the collaborative encoding in a distributed environment of cancer treatment protocols in Asbru. CliP-MoKi exploits the great flexibility of SMW technology to mix unstructured information and semantic annotations, allowing to automatically generate the final formal model with minimal adaptation cost. CliP-MoKi uses forms and a graphical representation of the resulting plan hierarchy to help the encoding and the representation of the model. All these features render CliP-MoKi a natural candidate for small to medium scale modeling tasks, since the use of bigger systems may require a big adaptation and training effort. Moreover, our approach is not constrained to Asbru, but CliP-MoKi can be adapted to support other modeling languages.

1 Introduction

Practitioners compliance with clinical protocols and outcomes can be promoted and improved by guideline-based computerized Decision Support Systems (DSS) providing automated support at the point of care, especially if integrated with the clinical workflow [1]. Clinical protocols adapt the available knowledge in books, articles, and clinical guidelines to the local resources and conventions at a specific site. While they are more concise than clinical guidelines, they still can easily be constituted by several tens of pages and handling them in paper form in daily practice can be tedious. The conversion of informal protocols in some machine interpretable format is a fundamental step in the provision of automatic support at the point of care. The transformation effort is smaller for protocols than for guidelines, since the former are more structured and focused on the care process carried on in the specific healthcare organization in which they are used. Nonetheless, it is far from trivial, and requires the close collaboration of physicians and knowledge engineers, who may not be located in the same place, and may not be able to physically participate in meetings. In this paper, we present CliP-MoKi (Clinical Protocols Modelling wiKi), a Semantic Media Wiki

M. Szomszor and P. Kostkova (Eds.): E-Health 2010, LNICST 69, pp. 135–143, 2011.

(SMW)-based tool for the collaborative encoding of cancer treatment protocols in a distributed environment, focusing on the Asbru language [2] as the target guideline modeling language. The tool, the first version of which was developed inside the Oncocure project [3], exploits the great flexibility of SMW technology to mix unstructured information and semantic annotations, which allow generating automatically the final formal Asbru model with minimal adaptation cost. In addition, semantic forms and a graphical representation of the resulting plan hierarchy are used to help the encoding and the comprehension of the model. The proposed approach allows remotely located people to actively participate to the encoding of cancer protocols into a skeletal but valid Asbru model. These features render our tool a natural candidate for small to medium scale modeling tasks, since the use of more complex encoding frameworks may require a big adaptation and training effort.

The paper is structured as follows: in Section 2 we describe our approach towards collaborative modeling. In Section 3 we describe a motivating scenario from the Oncocure project, while in Section 4 we present CliP-MoKi in detail. Finally, in Section 5 we discuss the related work and we draw some concluding remarks.

2 A Collaborative Approach to Modelling

Building a formal model of clinical protocols usually requires a number of skills. These skills, which span from having knowledge about diseases and treatments, to having knowledge about clinical protocols, to having the ability of encoding such knowledge into formal computer-processable statements, are hardly findable all together in a single person. For example, physicians have the knowledge to grasp the deep clinical meaning integrated in the protocols, but usually they lack the capability of making this knowledge explicit in a formal model. Similarly, knowledge engineers have the background and the training necessary to translate informal knowledge into adequate mathematical/computational models, but they have no, or very little, understanding of the clinical protocols. Furthermore, physicians may even have different degrees of expertise on the different aspects of clinical protocols. For these reasons, modelling clinical protocols is inherently a collaborative activity, performed by different actors (the *encoding team*) and carried on under some collaborative protocol.

To support collaboration between the encoding team, and to allow great flexibility in the cooperative modeling activity, we propose a *collaborative modelling* paradigm, illustrated in Figure 1. This paradigm is inspired by recent Web 2.0 collaborative solutions, e.g. wikis, and was proposed in [4] as a way to support modeling activities. In this paradigm all the actors asynchronously collaborate toward the encoding of clinical protocols by inserting knowledge (either formal or informal), by transforming knowledge (from informal to formal) and by revising knowledge. The physicians enter the missing knowledge - using a form of informal language - into the models or provide feedback on the Asbru model. The system provides support for translating the informal knowledge into a formal

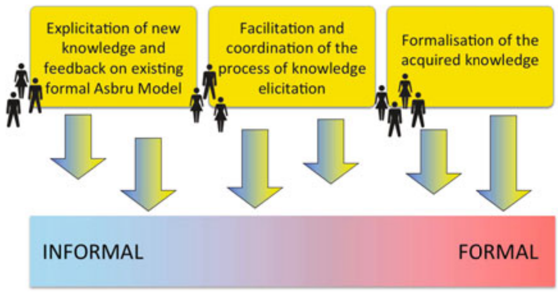

Fig. 1. Collaborative modelling protocol

specification and vice-versa. Asynchronously, the knowledge engineers can refine the formal model by inserting new elements, by modifying existing knowledge or by asking clarifications to the physicians. The usage of a robust collaborative technology, as the one provided by the wiki, enables the different actors to access the tool in a truly collaborative manner. Another important advantage of this approach relies in the capability of the system to maintain the alignment between the informal specification of the clinical protocols and their formal Asbru version. This can provide an added extra value, as the documentation contained in the informal part is often critical to fully understand its formal version.

3 A Motivating Scenario from the Oncocure Project

The aim of the Oncocure project[1] was the design and develop of an Asbru-based prescriptive DSS integrated with the legacy oncologic Electronic Patient Record in use in the Medical Oncology Unit (MOU) of the S. Chiara hospital of Trento, for supporting oncologists in the main decision steps of the provision of medical treatment to breast cancer patients. The first phase of the project was the knowledge acquisition task for encoding in Asbru the protocol of breast cancer treatment defined and used in the MOU. The protocol is a distillation of national and international guidelines and consensus conference recommendations, conceived as an easily readable reference document. It mainly consists of informal diagrams and explanation text. In the case of the Oncocure project, the modeling phase required collaboration between oncologists and knowledge engineers located in Trento and in Vienna. To this end, regular meetings in Trento between a breast cancer specialist of the MOU and a knowledge engineer were held. The knowledge engineer conducted non-standardized interviews with the oncologist to gather inputs about the whole care process. The oncologist's answers were written as informal text and then analyzed and discussed with the knowledge engineer in Vienna, who encoded the model in Asbru. The design of a lightweight collaborative tool was motivated by (i) the necessity of supporting

[1] Oncocure (2007-2009) was partly funded by Fondazione Caritro of Trento, Italy.

collaboration between remotely located participants to the encoding activities, (ii) favouring a more active involvement of physicians to the modelling process, (iii) supporting automatized translation of the informal protocols specifications to a formal task network language, and (iv) having a tight integration between the documentation contained in the informal specification and the formal model.

4 CliP-MoKi: The Clinical Protocols Modelling wiKi

CliP-MoKi[2] is based on Semantic MediaWiki (SMW) [5], a tool supporting the integration of Web 2.0 and Semantic Web approaches [6] that have been developed to meet the needs of the semantic modeling community to easily create, share, and connect content and knowledge. The choice of developing CliP-MoKi on top of a semantic wiki was made for several reasons. First of all, wikis are web-based systems, that is they are accessible virtually by every place in the world: this feature is particularly suitable since members of the encoding team may not be located in the same building, or even in the same town, and may not be able to physically participate in meetings. Due to the growing popularity of wiki-based web sites (e.g. wikipedia), users are quite familiar with wikis and the editing of wiki pages. Furthermore, the SMW framework already provides many important functionalities such as robust collaboration support, access control and permissions, tracing of the activity, semantic search, and so on, without the need to install specific client applications. Finally, only a web-browser is required on the end user side to use the system. Another relevant reason for implementing CliP-MoKi on top of a semantic wiki is that the natural language descriptions inserted in a semantic wiki can be structured according to predefined templates, with the help of semantic constructs like properties. As a consequence, the informal descriptions in natural language contain enough structure to be automatically translated in formal models, thus allowing the reuse of informal descriptions for the automatic Asbru model creation.

ABRU plans in CliP-MoKi*.* The main idea behind CliP-MoKi is that an Asbru guideline model is expressed as a collection of interrelated wiki pages connected by typed links. A wiki page is associated to each element of an Asbru guideline model so that this page contains an informal but structured description of the element itself. The typical page comprises two main parts. The first part stores an informal description of the element in natural language (images or drawings can be attached as well). The purpose of this part is to document the model and clarify it to users not trained in the formal representation (e.g., reference to source documents, open problems, etc.); moreover, users can also add comments in this part. The second part of the page is the structured part, where the element is described by means of triplets of the form *(subject, relation, object)*, with the element itself playing the role of the subject. The purpose of this part is to represent the connection between the elements of the Asbru models (e.g., a

[2] Try CliP-MoKi on-line at `http://moki.fbk.eu/clip-moki/tryitout`

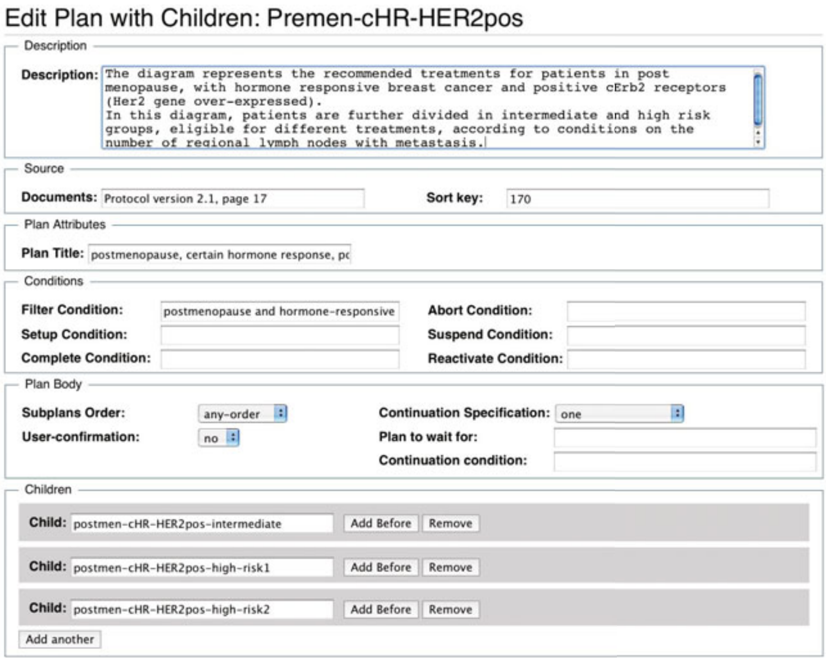

Fig. 2. An example of CliP-MoKi page

plan and its subplans), as well as the element data that must be present in the model (e.g., the title of a plan).

This natural language based, but also structured, description provides an ideal bridge between formal and informal representation of the clinical protocols. The user fills a page via forms, so he/she does not need to know any particular syntax or language to participate in the creation of the Asbru model. All the actors involved in the modelling activities can also interact with each other and exchange further ideas and comments using the *discussion* SMW's built-it functionality. Figure 2 shows an example of CliP-MoKi page.

The structured part of each CliP-MoKi page is organized via template according to the type of Asbru building block it is meant to represent. For the first versions of the tool, we have defined a template for each plan body type (plan with subplans, plan activation, ask, user performed, cyclical plan, variable assignment, if-then-else), two templates for parameters (raw data definition and qualitative parameter definition), and two templates for abstractions (qualitative scale definition and secondary qualitative entry). This is the set of building blocks that currently CliP-MoKi allows to edit, although we are working on extending it. In the current release, conditions on plan state transitions can only be sketched in free text in the CliP-MoKi page (e.g. to be refined and formalized outside CliP-MoKi) and we currently investigating the possibility to express them directly in the CliP-MoKi page in a user-friendly but structured manner (e.g. by

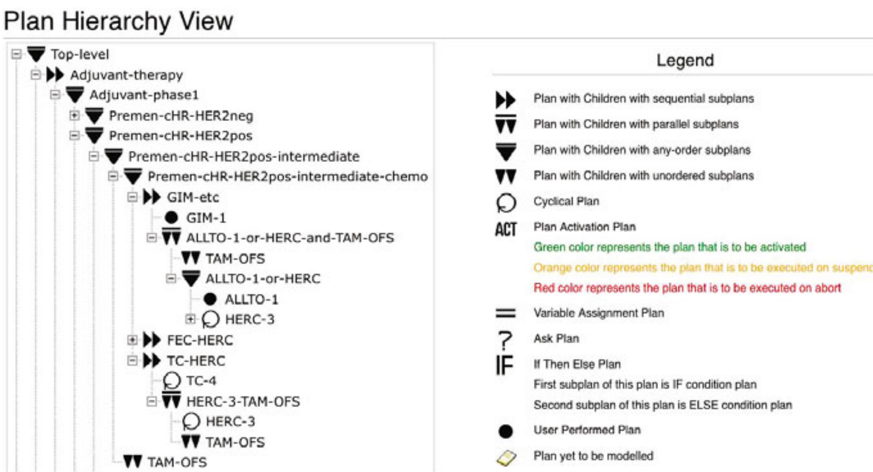

Fig. 3. Plan Hierarchy View

using controlled natural language tools). This would help to maintain a precise and automatically preservable alignment between the conditions expressed in CliP-MoKi and those in the XML serialization of the Asbru model.

Functionalities of CliP-MoKi*.* To support the creation of an Asbru model, CliP-MoKi provides groups of functionalities that can be accessed via a sidebar menu.

Import. With this functionality the user can set-up CliP-MoKi with an already available XML serialization of an Asbru model. The aim of this functionality is twofold: on the one hand, it allows to show in a user-friendly way a formal Asbru model to users not familiar with formal models; on the other hand, the loaded Asbru model could be (re)used as a starting point to develop a new model, instead of modelling from scratch.

Model Management. This is a set of functionalities that supports the user in the creation, editing and deletion of pages that describe model elements.

Visualization. This is a set of functionalities that allow producing different types of overviews of the models: they help the users to deal with the global picture on the model and not only with the single model elements. In the tabular-based visualization, the user get a table listing the elements of the model filtered by type (e.g. all the plans with children, all the parameters), together with some relevant information (e.g. plan type, order of subplans). In the graphical-based visualization, the *Plan Hierarchy View* (see Figure 3), a tree-like view shows how plans are related with their subplans. This view is dynamically created from the content of the CliP-MoKi pages. The user has the possibility to expand/collapse only parts of the tree, thus allowing him/her to efficiently browse even large and complex models. Beside the plan name, an icon is used to represent in a concise and intuitive way the plan type (e.g. in Figure 3, *HERC-3* is a cyclical plan).

Export. This functionality supports the automatic export of the model described in CliP-MoKi to an Asbru XML model according to the Asbru DTD. This model has those fields set to a final value, for which sufficient and precise information is available in CliP-MoKi.

CliP-MoKi is built in a modular way in order to facilitate the plugging-in of new or existing tools which may complement the current functionalities.

5 Related Work and Conclusion

Several recent experiences are reported in literature on the use of wiki technology for knowledge acquisition in the biomedical informatics field, most of them for managing genomic or proteomic data. Among the others, BOWiki [7], an extended SMW for the collaborative annotation of gene information, and Array-Wiki [8], a wiki-based system for the user-friendly and distributed management of meta-data of microarray meta-experiments. Meenan at al. [9] describe an implementation of a wiki-based knowledge base for disseminating technical expertise in a radiological department. Recently, several initiatives are beginning to use Web 2.0 technologies and paradigms to share and collaborate on decision support content. [10] describes three efforts in this direction: Clinfowiki, Partners Healthcare eRooms, and Epic Systems Corporation's Community Library. As far as we know, no wiki-based tool has been developed so far for the specification of clinical protocols.

Uruz-DeGeL is a comprehensive web-based infrastructure [11] which enables clinician and knowledge engineers at different sites to collaboratively specify and mark-up guidelines in three representation levels: semi-structured, semi-formal and formal. The guideline can be structured according to the selected target GL ontology (e.g., Asbru). The aim of our work was to develop a more lightweight infrastructure that requires little effort to install, get acquainted with and use, in order to promote a more active involvement of physicians in the modelling process. We believe that this approach could be particularly adequate in situations where the effort of learning and using more complex and fully-featured tools may not be justified.

CliP-MoKi presents many features, which we briefly recall:

- the provision of a lightweight infrastructure that allows each member of the encoding team to easily follow and contribute to the encoding process;
- the possibility to mix informal content with semi-formal fragments;
- the possibility to get a compact and intuitive graphical overview of the clinical protocols specified, and in particular of the plan-subplans hierarchy;
- the automatic generation of valid skeletal Asbru models from the informal specification;
- the user-friendly representation of already available Asbru formal models;

- its modular-like structure makes it easily extensible with additional functionalities, like alternative visualisations of the specifications, or plug-ins to support the early stages of the knowledge acquisition process;
- although our work is focused on using Asbru as encoding language, CliP-MoKi can be generalized to collaboratively encode protocols in other languages, by defining templates with slots specific for the language used.

The usage of CliP-MoKi to specify clinical protocols currently assumes that these protocols have been already well-structured before to start using the tool. While we plan to extend CliP-MoKi with functionalities to support the early stages of modeling, we also believe that this is not a major issue for the tool, since in many real situations and hospital wards, a structured representation of the protocols is routinely prepared by physicians as a reference document immediately usable in the daily clinical activities.

Apart from enriching the current set of functionalities, and extending the coverage of the building blocks that are representable by the tool, a full evaluation of CliP-MoKi is one of the future activities we have already planned. Some preliminary but informal feedback on its usability is encouraging: the oncologist involved in the Oncocure project expressed a positive attitude toward this collaborative modeling tool, because she was able to easily understand and verify the knowledge engineers's modeling work. CliP-MoKi, however, still requires the knowledge of the Asbru meta-model to correctly complete the semantic tags; it does not solve the problem of allowing domain expert untrained in formal task network languages to encode medical knowledge. This is a problem shared by all knowledge acquisition projects however, and its solution requires a broader approach than just applying software.

References

1. Sonnenberg, F., Hagerty, C.: Computer interpretable guidelines: where are we and where are we going? 2006 IMIA Yearbook of Medical Informatics, Methods Inf Med. 45(suppl. 1), S145–S158 (2006)
2. Seyfang, A., Kosara, R., Miksch, S.: Asbru 7.3 reference manual. Technical report, Vienna University of Technology (2002)
3. Eccher, C., Ferro, A., Seyfang, A., Rospocher, M., Miksch, S.: Modeling clinical protocols using semantic MediaWiki: the case of the Oncocure project. In: Riaño, D. (ed.) K4HelP 2008. LNCS, vol. 5626, pp. 42–54. Springer, Heidelberg (2009)
4. Christl, C., Ghidini, C., Guss, J., Pammer, V., Rospocher, M., Lindstaedt, S., Scheir, P., Serafini, L.: Deploying semantic web technologies for work integrated learning in industry. a comparison: Sme vs. large sized company. In: Sheth, A.P., Staab, S., Dean, M., Paolucci, M., Maynard, D., Finin, T., Thirunarayan, K. (eds.) ISWC 2008. LNCS, vol. 5318, pp. 709–722. Springer, Heidelberg (2008)
5. Völkel, M., Krötzsch, M., Vrandecic, D., Haller, H., Studer, R.: Semantic Wikipedia. In: WWW 2006, Edinburgh, Scotland, May 23-26 (2006)
6. Noy, N., Chugh, A., Alani, H.: The CKC challenge: exploring tools for collaborative knowledge construction. IEEE Intelligent Systems 23(1), 64–68 (2008)
7. Backaus, M., Kelso, J.: BOWiki - a collaborative annotation and ontology curation framework. In: WWW 2007, Banff, Canada, May 8-12 (2007)

8. Stokes, T.H., Torrance, J.T., Li, H., Wang, M.D.: ArrayWiki: an enabling technology for sharing public microarray data repositories and meta-analyses. BMC Bioinformatics 9(suppl. 6), S18 (2008)
9. Meenan, C., King, A., Toland, C., Daly, M., Nagy, P.: Use of a wiki as a radiology departmental knowledge management system. J. Digit. Imaging 23(2), 142–151 (2010)
10. Wright, A., Bates, D.W., Middleton, B., Hongsermeier, T., Kashyap, V., Thomas, S.M., Sittig, D.F.: Creating and sharing clinical decision support content with web 2.0: Issues and examples. J. of Biomedical Informatics 42(2), 334–346 (2009)
11. Shalom, E., Shahar, Y., Taieb-Maimon, M., Bar, G., Yarkoni, A., Young, O., Martins, S., Vaszar, L., Goldstein, M., Liel, Y., Leibowitz, A., Marom, T., Lunenfeld, E.: A quantitative assessment of a methodology for collaborative specification and evaluation of clinical guidelines. J. of Biomedical Informatics 41, 889–903 (2008)