Facilitating Knowledge Maintenance of Clinical Guidelines and Protocols

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Abstract

Clinical protocols and guidelines are widely used in the medical domain to improve disease management techniques. Different software systems are in development to support the design and the execution of such guidelines. The bottleneck in the guideline software developing process is the transformation of the text-based clinical guidelines into a formal representation, which can be used by the execution software. This paper introduces a method and a tool that was designed to provide a solution for that bottleneck. The so-called Guideline Markup Tool (GMT) facilitates the translation of guidelines into a formal representation written in XML. This tool enables the protocol designer to create links between the original guideline and its formal representation and ease the editing of guidelines applying design patterns in the form of macros. The usefulness of our approach is illustrated using GMT to edit Asbru protocols. We performed a usability study with eight participants to examine the usefulness of the GMT and of the Asbru macros, which showed that the proposed approach is very appropriate to author and maintain clinical guidelines.

Keywords

Clinical Guidelines, Standards and Protocols, Knowledge Acquisition, Validation/Verification, and Maintenance

Introduction

Currently, the medical staff are facing two major problems: the information overload resulting from modern equipment, and the need to improve the quality of health care through increased awareness of proper disease management techniques. Clinical protocols and guidelines should help to solve those problems. "*Clinical guidelines are systematically developed statements to assist the medical practitioner and patient in making decisions about appropriate healthcare for specific circumstances*" [2].

Therefore, in the last couple of years various kinds of guideline-supporting methods and tools were introduced which range from guideline authoring methods to sophisticated guideline execution environments. For example, *Asbru*View [3] is a knowledge acquisition and visualization tool, which was developed within the *Asgaard* project[1] [4],[9] to facilitate the creation, authoring, and visualization of clinical protocols written in *Asbru* [5],[8].

1. *Asgaard* Project website: http://www.asgaard.tuwien.ac.at/

To be suitable for physicians, *Asbru*View uses graphical metaphors, such as a running track with a finishing flag, to represent *Asbru* plans. *GEM Cutter* [7] is a tool that was developed to support the transformation of a guideline into the GEM format. It shows the original guideline document together with the corresponding GEM document, similar to our *Guideline Markup Tool*, and makes it possible to copy text from the guideline to the GEM document. Guide-X / Stepper [11] [12] is a methodology (there is no implementation yet) that describes a way to translate a guideline into a computerized form. The formalization process is divided into 5 steps, whereas each step has an exactly defined input and output. There are two tools for translating guidelines into PRO*forma* [1] (i) AREZZO is designed to be used on client-side only, whereas TALLIS [10] supports publishing of PRO-*forma* guidelines over the World Wide Web. Other projects rely on general knowledge acquisition tools, like *Protégé* [6], to create guideline.
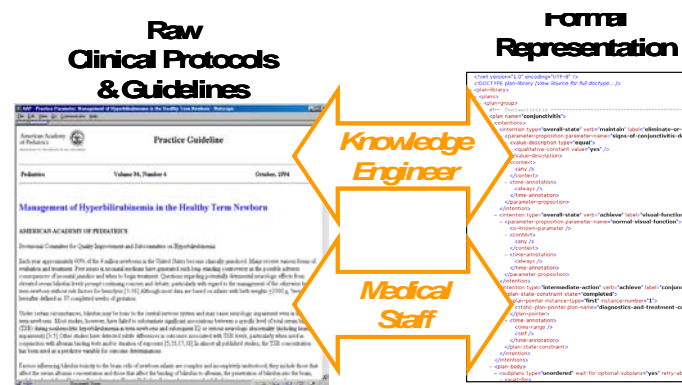

Figure 1 - The basic idea.Translating a free-text guideline into a formal representation supporting the tasks of the knowledge engineer as well as the medical staff

Nevertheless, the bottleneck in clinical guideline and protocol development cycle is the acquisition, validation/verification, and maintenance of such guidelines. The existing guideline tools have their inherent advantages and disadvantages, but they have all one common drawback. They do not provide any possibility to establish connections between the original guideline and its computerized version. For example, if the validation of a guideline written in a formal representation leads to contradictions, it would be helpful to see the corresponding parts of each inconsistence in the original guideline. We have developed a tool that

provides such features, called *Guideline Markup Tool* (GMT). It allows the creation of links between the original guideline and its representation in a formal notation (compare Figure 1) – in our case the *Asbru* language. Furthermore, it facilitates assembling an *Asbru* guideline, by providing macros, which combine Asbru elements into larger building blocks.

In this paper we will explain the main features of the GMT and the results of the evaluation study. Finally, we present some possible improvements.

Method: The Guideline Markup Tool (GMT)

Currently, only limited supporting tools for the knowledge engineers exist, which translate a guideline available in free text into a guideline-representation language or a formal representation language, like *Asbru* (compare Figure 1). Since many clinical guidelines are published over the World Wide Web using the HTML format, an appropriate tool should provide an HTML view. Showing this view together with the content of the XML file (which supports the viewing of the formal representation) would facilitate the translation task. This leads us to the main idea of the *Guideline Markup Tool* (GMT)[1] [13] (see Figure 2).

GMT is a tool that helps translating guidelines in free text into a formal representation, by providing two main features: *(i)* linking between a textual guideline and its formal representations, and *(ii)* applying design patterns in the form of macros. The GMT can deal with any formal representation defined in XML, but the macros are typically tailored towards a particular guideline representation language. In the following we illustrate the features of GMT using the guideline-representation language *Asbru*.

Firstly, GMT allows the definition of links between the original guideline and the *Asbru* representation, which gives the user the possibility to find out where a certain value in the *Asbru* notation comes from. Therefore, if someone wants to know the origin of a specific value in the *Asbru* XML file, the GMT can be used to jump to the correlating point in the HTML file where the value is defined and the other way round.

The second main feature of the GMT is the usage of macros. A macro combines several XML elements (in other words, *Asbru* elements), which are usually used together. Thus, using macros allows creating and extending *Asbru* XML files more easily through the usage of common design patterns. Such design patterns are often used algorithm and behaviours , which can be found in guidelines.

Through these two features, GMT is able to support the following tasks:

- **Authoring and Augmenting Guidelines.** We want to be able to take a new guideline in plain text and create an *Asbru* version of it, and to add links between the corresponding parts of a guideline and an already existing Asbru file.
- **Understanding *Asbru* Guidelines.** For an *Asbru* guideline, we want to be able to see where certain values in

the different parts of the *Asbru* guideline come from, and how parts of the original text were translated into *Asbru*. This is important not just for knowledge engineers, but also for physicians wanting to get an understanding of the language *Asbru*.

- **Structuring *Asbru*.** The GMT provides a list of *Asbru* elements – the macros – that needs to be structured in a way that best supports the authoring of plans. This list will also provide a good starting point for teaching material and defining particular subsets of the language for particular algorithmic purposes (for example, administering drugs).
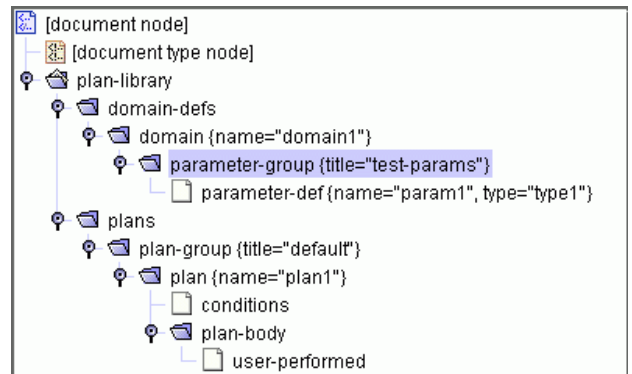
Figure 2 -   Resulting XML document. The contents of the macro are inserted as child elements.
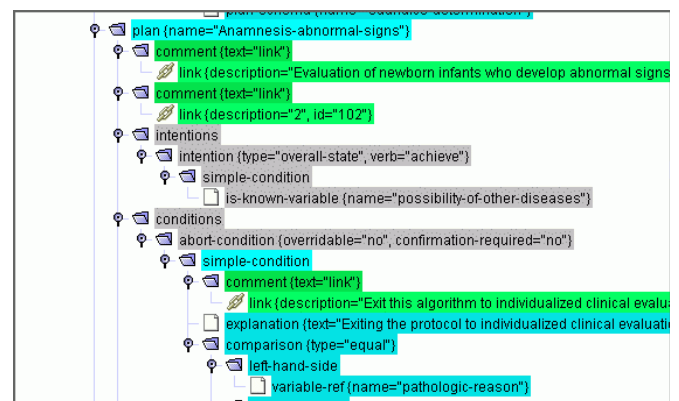
Figure 3 -   Visualization of links in an Asbru *macros file. The link elements have a green background, the elements, which are in a subtree that contains one ore more links are colored blue, and the other elements are gray.*

Features of the Linking Part

According to the requirements presented above, the user interface is designed to show the contents of an HTML file (original guideline), an XML file (*Asbru* representation) and a macros file together in one window. Therefore, the GMT window is divided into three main parts – Figure 4 shows a screenshot of the GMT with loaded HTML-, XML- and macros files. The upper left part of the window (component #1 in Figure 4) shows the contents of the HTML file. The XML part consists of a hierarchical view of the XML file (component #2a) and a detail view of the current XML node (component #2b). The macros part contains a view

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of the macros structure (component #3a) and a pre-view of the currently selected macro (component #3b). The following three main features are supported:

- **Inserting a macro/link.** To insert a macro (or a link, which is a special kind of macro), the target XML element in the XML view and a proper macro in the structure view have to be selected. After clicking on the insert-macro button the contents of the macro are inserted into the currently selected XML element (see Figure 2).
- **Activate a link.** If links have been defined during the translation of a guideline, they can be used to comprehend the connections between the original guideline and its Asbru representation (see Figure 5).
- **Link visualization.** A useful add-on is the possibility to visualize the spread of links in an Asbru file, where each element in the XML view gets coloured differently – all link elements get a green background, the elements that belong to a link, are coloured blue, and the other elements are grey. In case links are inserted into an existing Asbru file, this feature provides a good overview of all unlinked parts (see Figure 3).

Features of the Macros

To demonstrate the usability of the GMT, a macros file providing macros for the work with *Asbru* files was developed. Asbru experts modelling various guidelines in Asbru helped designing these macros. To turn it into a highly sophisticated macros file, future research, including a detailed analysis of the various kinds of informal medical guidelines to derive macros as design patterns, will have to be done. Table 1 shows the source code of a sample macro compared to its representation shown in the GMT and to the resulting target *Asbru* XML code.
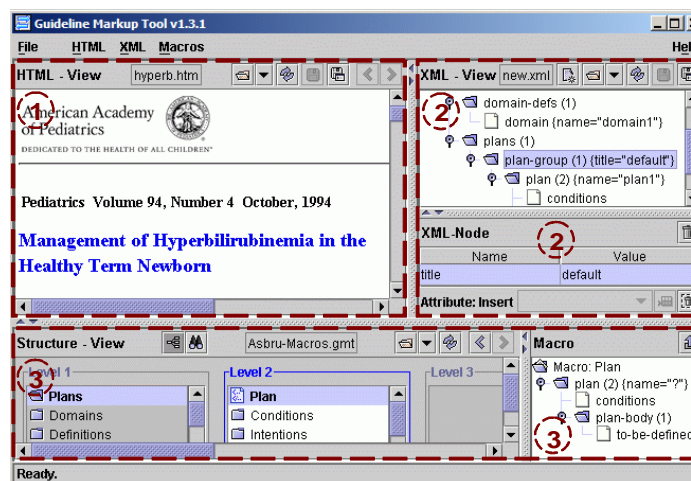

Figure 4 - Screenshot of the GMT window

Evaluation

We performed a small, qualitative study on the usability of the GMT. We chose eight knowledge engineers, who were familiar with the *Asbru* language (two of them were even *Asbru* experts).

The evaluation procedure consisted of three phases:

(i) a questionnaire assessing the skills of the participants;

(ii) an exploration session, where the participants examined the functionality of the GMT;

(iii) a questionnaire assessing the overall impression and the three views in particular.

The first phase showed that the sample was quite homogeneous, having similar skills (e.g., knowing various programming languages and software). However, the medical knowledge in the group, in particular knowledge about guideline-based care, was quite limited

The second and third phase confirmed that the three views (HTML, XML, Structure View) are very appropriate to author and structure clinical guidelines and to translate such clinical guidelines into a formal notation, like Asbru. The linking features in both directions facilitated structuring guidelines' text, the retrieval of knowledge parts, and retracing of possible flaws and errors. One drawback of the GMT was that everybody was expecting a fully functional XML editor for in the XML View. However, we were not focusing on such an editor, but features like copy, cut and paste or drag&drop were requested. Finally, the macros helped the participants to understand and write better *Asbru* code, however, this part needs more guiding features and design patterns to write *Asbru* guidelines more easily. In summary, the participants rated the GMT as a very powerful and useful tool, which will support the implementation of clinical guidelines.
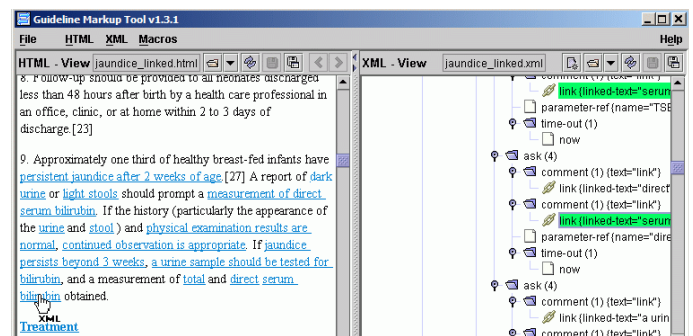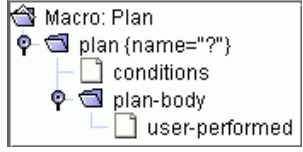

Figure 5 - Link activation. When clicked on a link endpoint in the HTML view, the counterparts are highlighted in the XML view

More detailed analyses and results of the study can be found in [13].

Conclusions and Future Work

In this paper, a new guideline tool, called *Guideline Markup Tool* (GMT), is introduced. It supports knowledge engineers in translating clinical guidelines into a formal representation – we illustrated the power of the GMT applying the method to the implementation of clinical protocols written in *Asbru*. It does this by providing macros to facilitate assembling *Asbru* guidelines. A macro contains a structure of *Asbru* elements, which belong together.

Table 1: Macro Plan. It can be used to insert a new plan together with the most important plan accessories. The name of the plan will be asked from the user (as defined by the «?»)

Macros File	Result
```<macro name="Plan"> <element-ref name="plan"> <attribute-ref name="name" value="?"/> <element-ref name="conditions"/> <element-ref name="plan-body"> <element-ref name="user-performed"/> </element-ref> </element-ref></macro>```	 ```<plan name="?"> <conditions/> <plan-body> <user-performed/> </plan-body></plan>```

But the main feature of the GMT is the ability to create and maintain links between a guideline HTML file and its representing *Asbru* XML file. The knowledge engineer should always define links during the translation task. If the resulted *Asbru* XML file is used as an input of another *Asgaard* tool, it may happen that someone wants to know the reason for the choice of a particular *Asbru* element or the origin of a specific attribute value. The GMT can be used to answer such questions or to retrace errors.

To be consequently, links also work in the other direction, which allows easier comprehension of the translation process and thereby facilitates learning of the quite complex language *Asbru*. Therewith, the GMT can be used to find out how a particular passage in the text of the original guideline has been modelled in *Asbru*.

To demonstrate the applicability of the macros and to increase the usefulness of the GMT, a prototype of an *Asbru* macros file was developed.

The evaluation of the GMT has shown that there are still some features missing, primarily to facilitate the work with the GMT in practice. Certainly, the most needed feature during the evaluation was the ability to undo the last action. Another demanded feature was for example copy/cut/paste of XML nodes. A complete list of all projected improvements regarding the GMT can be found in [13] .

Since the *Asbru* macros file is still in progress, there is enough room for improvements, too. The next step regarding the macros file is to perform another user study, to find out which macros should be improved and which macros are missing.

Acknowledgments

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