Visualizing Topic Maps for e-Learning

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Abstract

TM4L is an e-learning environment providing editing and browsing support for developing and using Topic Maps-based digital course libraries. The TM4L functionality is enhanced by an interactive graphical user interface that combines a hierarchical layout with an animated graphical view, coupled with context sensitive features. This paper discusses the visualization design in TM4L and some development issues. The focus is on the TM4L Viewer, its functionality and GUI.

1. Introduction

Knowledge standards, such as Topic Maps (TM) [1], make it possible to incorporate learning content in semantically rich data models. Developing good graphical user interfaces (GUI) in TM-based applications though is a challenge. GUI used in the available general topic maps editors and viewers such as Ontopia's Omnigator (http://www.ontopia.net/), TM4J TMNav (http://tm4j.org/tmnav.html), etc. cannot support particular ontological needs or domain specific vocabularies. They tend to use TM model-related terminology and labels, such as associations, occurrences etc. in their presentation. Specialized TM-based e-learning applications require interfaces that support the e-learning objectives coupled with ontology support for classification, navigation and exploration of concepts, instances, relationships and resources in the considered subject domain.

We have developed TM4L (Topic Maps For e-Learning) - an ontology-based environment to complement existing TM editors and visualization tools for the area of e-learning. It is based on the TM4J open source project (http://tm4j.org/) and combines two main applications, the TM4L Editor and TM4L Viewer. The modeling language of TM4L [2][3] is based on the TM standard [4]. TM4L targets two groups of users:

- Topic Maps authors/instructors (typically with a limited background of ontologies).
- Learners seeking online information support when performing their learning tasks.

The driving factors guiding our design decisions with regard to TM4L information representation and visualization lie in the balance between simplicity and expressivity. Some of the key questions in this aspect include:

- What does the representation mean to authors and to learners?
- Does the representation model enable easy articulation of the classes of concepts and their instances and relationships?
- Is it immediately apparent which items belong to one or to multiple classes, which classes overlap and which don't?
- Does it reveal the vocabulary of the subject domain?

The motivation behind TM4L is to enable authors with limited knowledge of information technology to populate and maintain an e-learning repository relatively easily. The term "visualization" is used in this work in a broader sense: it refers to the appearance of the textual and graphical information in combination with the employed information visualization techniques.

TM4L is currently available as standalone application. It can be downloaded from http://www.wssu.edu/iis/nsdl/download.html. In this paper we discuss issues related to the visualization implemented in TM4L.

2. Design Considerations

Task-based learning emphasizes learners own efforts in the learning process including their independent information seeking. Working on their tasks (such as home assignments and projects) the students need to gather information from different sources in order to complete a task. Task-based learning typically leads students to diversified and active usage of various

sources of information. Information seeking in e-learning context is a complex activity that originates from learner's information needs and involves some form of strategy in searching and browsing of a variety of information sources.

The TM4L interface was designed according to two basic principles. The first one is that learners and authors should maximize their interaction with the learning content and minimize their attention to TM4L itself. The second one is that browsing and search strategies should be both supported. These principles are embedded in the following goals:

1. Offer an insightful ontological overview of the learning collection stricture.
2. Provide the most important information at the earliest point.
3. Support rapid relevancy decision based on multiple views.
4. Support exploratory browsing to develop intuition.
5. Offer contextual support during search to allow users to express correctly their information needs.
6. Support different perspectives and allow comparing them or getting more information at a glance.
7. Offer possibilities for restricting the amount of displayed information (e.g. to selected topics of interest).

From Semantic Web perspective ontology-based information seeking is a promising approach for enhancing existing interfaces with features enabling learners to improve exploratory search styles and express better their information needs. This involves interactions with concepts and relations embodied in the ontologies that describe the subjects to be learned.

3. Support - Authors versus Learners

The functionality and the visualization strategy of TM4L are defined to support both groups of users: authors and learners. As usual, the first step in the design process was to identify TM4L users' needs. Learners and authors have different goals, different levels of subject domain knowledge and skills, and thus different needs for support. Concerning the goals, authors' task in the modern educational information systems, is not any more just to provide information. Instead their new task is to ensure support for the learning process and learner's independent information seeking, which plays an important role in all active learning methods.

The authors know the subject domain thus when searching a repository, they are typically aware of the target topics and want to get the available information related to them as quick as possible. However, they need support in structuring (finding the correct place in TM of) new information.

The learners, on the other hand, have often only a vague idea of what they need. For example, they may have limited knowledge of what they are looking for in terms of their current course tasks. The gap between what the learners understand and what they think they should understand often generates confusion.

The authors typically know the jargon of the field, while the learners frequently are not familiar with the terminology.

Thus authors and learners differentiate in:

- *Navigation and query formulation strategy*: Which path is more efficient to get information relevant to the needs? How to modify the query so as to find more relevant information?
- *Vocabulary knowledge*: Which terms to use?

The different ways of tackling these questions reflects the gaps in terms of knowledge and perception between the authors and the learners. In general, learners need to alternate phases of browsing the topic map content with phases of querying it. In the latter they often need to refine their selection criteria according to the obtained results.

In contrast, the authors' needs are centered on efficient support for organizing the learning content and making it more structured and accessible. This presumes functionality of supporting topic maps evolution which will enable the authors to modify the underlying ontology, instances and resources. As it was impossible to fulfill all support requirements completely, we adopted a compromised approach to the interface design. The interface should:

- Allow users who know what they are looking for to quickly and efficiently find it.
- Allow users who don't know what they are looking for to do *exploratory searching*.

Searching and browsing in TM4L are integrated so that users can move easily between the two options.

4. Visualization for Authoring

Visualizing and navigating ontology-based learning content is a challenging problem. In contrast to the general ontology editors, in the e-learning authoring tools instance information along with the resources is often as important as the structure of the ontology used

to describe them. Accordingly, the TM4L editing facilities enable users to represent the ontology schema along with instances of the defined classes, their properties, and related topics and resources.

Interfaces that provide multiple views are able to offer different perspectives on a selected entity. The TM4L Editor provides three different views: topic-centered, relation-centered and themes-guided (see Fig. 1).

As a primary relation for classifying learning content we have selected the *part-whole* relationship. Thus differently from typical ontology editors, TM4L builds topic *partonomy,* instead of taxonomy (based on class-subclass relations). The reason for this is the important explanatory role of partonomy in e-learning. Explaining what a learning topic/unit is about, often involves describing its parts and how are they composed. By emphasizing the compositional structure, partonomy is closer to the approach normally used by courseware authors for representing the learning content. In addition to the *part-whole* relationship TM4L contains four other predefined relation types: "superclass-subclass", "class-instance", "related-to", and "similar-to" [5][6] (see Fig. 1).

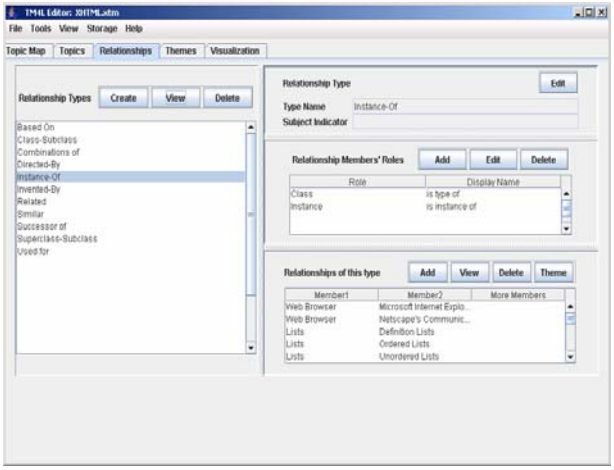

Figure 1. Screenshot of the TM4L Editor GUI: the Relationships view.

The TM4L Editor's Topic view interface is a tree rendering, with the left pane showing the tree and the right panes showing the properties of the currently selected node (topic). The nodes of the tree are topics and the edges denote the *part-of* relation. The tree allows browsing the topic hierarchy at different levels of detail. The topic attributes, resources and relations are displayed in separate panels.

5. The TM4L Viewer

We consider the exploration practice as the process of finding information that is relevant to the learner's current tasks. There is a tendency towards browsing in terms of exploration, and the TM4L Viewer should therefore be enhanced to better support both browsing and the combination of searching and browsing activities. The exploration practice differs from information querying in that no specific question needs to be answered. Instead, the user (learner) wants to know about relevant information at a more global level, e.g. to see what information is available in terms of their current information needs. Exploration also differs from general analysis in that the issue is not to oversee the entire collection in a holistic way but only inspect those parts relevant to the learner's current task. The exploration of large information spaces is a difficult task, especially if the user is not familiar with the terminology used for describing information. Conceptual models of a domain in terms of thesauri or ontologies can remedy this problem to some extent. Exploration on the level of concepts and relationships can be used as a navigating and query formulating mechanism fostering semantic exploration and discovery. In order such an ontological framework to be useful, there is a need for interactive tools for exploring large information sets based on conceptual knowledge.

The additional factors that have influenced our visualization strategy with respect to the TM4L Viewer include:

- *Target user group***:** e.g. students/ learners.
- *Intended use*: e.g. exploring, searching, comparing, making a decision for relevance, extracting information, etc.
- *Type of information to be displayed*: e.g. graph structures, hierarchical information structures, documents, links, etc.
- *Technical possibilities.*

These observations suggested in turn the following guiding principles with respect to the TM4L Viewer design:

- Design an information space that offers the learner an ontologically rich representation of information based on different information sources in an *integrated* fashion.
- Offer support for users with different levels of skills and different information needs.
- Design an easy to use system that supports learner's exploration in an effective and efficient manner.

- Design an easy to learn system that reveals to the learner all available possibilities for interacting with it.

To enable multi-purpose exploration the TM4L Viewer supports multiple views. Its visualization strategy is to provide a view on demand. Interfaces that provide multiple views offer users different perspectives on a selected entity.

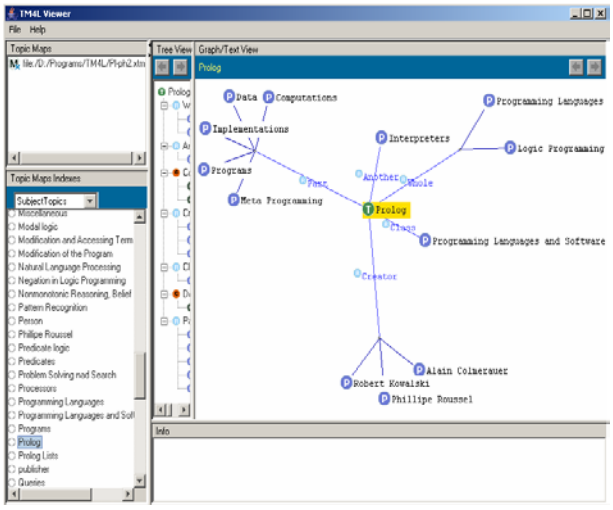

Figure 2. Screenshot of the TM4L Viewer GUI.

TM4L has been developed as a universal course task information support tool. Therefore, it has a general user interface, not dependent on a specific domain of knowledge. The goal is to provide an intuitive graphical interface for topic map-based learning content navigation. There are three views supported by the Viewer: *Graph View*, *Text View,* and *Tree View*. These views are intended to ease navigation at "hot spots". The graph view includes a semantically expressive, browsable graph (based on TouchGraph) (see Figure 2).

The interface allows browsing all the topics and relationships defined in the topic map as well as filtering some views with respect to selected topic types or relationships. The visual display is not intended to convey the full richness of a TM-based repository, but to show which topics are present and how are they related. Aiming at reducing the information overload, we have chosen at each navigation step to display only the topics most immediately related to the currently selected object. In addition, we have chosen not to show the resources associated with the displayed topics in the Graph view, since the visualization becomes too crowded and unclear. Thus the Graph view represents only 'ontology' objects - topics, relationships, roles (the latter can be also hidden) but not resources.

The TM collection can be viewed from different perspectives: Subject Topics, Relationships, Topic Types, Relationship Types, Resource Types, and Themes.

The TM4L Viewer supports this by offering six corresponding indexes. These indexes provide the starting point for browsing the topic map. When the user selects a particular object (the "focus" object - topic, relationship, etc.), from an index, the corresponding topic map object will be displayed in the "Tree View" and the "Graph/Text View" panels of the Viewer's window. The view in each panel can be changed to any of the other two. The user can continue browsing the learning content by selecting an object related to the currently displayed one. When navigating, the user can choose in which panel the information about the selected topic to be displayed. This allows browsing different objects related to the current one without loosing the focus.

By exploring the graph in a particular direction the user can obtain a better understanding of its content and thus decide what portion of the repository is relevant to their needs. The following are additional options provided by the TM4L viewer.

- *Visualization manipulation***:** the user can move the graph as well as re-organize its topological structure, according to his or her needs.
- *Graphical selection:* the selection of a single topic at a time in the Graph/Text/Tree view allows the user to select an object for expansion and thus to select a particular direction for exploration of the topic map. By selecting a new object from the topic map index it is possible to select a new starting point for exploration.
- *Context representation: context/theme* filters can be applied to the content shown in the Viewer. Every topic characteristic may have a scope, which is specified explicitly, as a set of *themes*. A theme is a topic that is used to limit the validity of a set of topics and relations. The objects that are not valid in the specified theme are filtered out.
- *Highlighting:* whenever an element of the visualization is selected it is highlighted showing the current context.

The user interface will only expose small portions of the topics at any time. The TM4L Viewer provides an animated and zoom-able view with context sensitive features like click-able topics or selective detail views. For more details see http://www.wssu.edu/iis/nsdl/viewerUserGuide.html.

The implementation of the TM4L Viewer is based on TMNav, which is part of the TM4J open source project (http://tm4j.org/). The whole development process was (and will continue to be) accompanied by formative and summative evaluation studies to "proof the concept".

4. Conclusion

As the ontology-aware learning content continues to grow, the need for editing and visualization tools will intensify. Painless creation of ontological structures for e-learning depends on two factors: an available initial predefined ontology that releases the author from the task of creating basic terms and relationships and a user-friendly interface that permits the author to create metadata instances intuitively. From learner's perspective the quality of an e-learning information support system depends on both the functionality, enabling intuitive exploration of the learning content and the power of the employed methods for searching the collections. The TM4L interface provides a sufficiently intuitive exploratory framework for editing and exploring learning objects collections, which supports browsing the learning content map, exploring related topics, and viewing the resources related to the topics of interest.

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References

[1] Park, J., Hunting, S.: *XML Topic Maps: Creating and Using Topic Maps for the Web,* Addison-Wesley (2002).

[2] Dicheva D., Dichev C.: Educational Topic Maps, *3rd Int. Semantic Web Conference* (ISWC'2004) Poster Abstracts, Hiroshima, Japan (2004) 19-20.

[3] Dicheva D., Dichev C., Sun, Y., Nao, S.: Authoring Topic Maps-based Digital Course Libraries, *Proceedings of the Workshop on Applications of Semantic Web Technologies in e-Learning 2004* (*SW-EL@AH'04*,) Eindhoven, The Netherlands (2004) 331-337.

[4] Biezunski, M., Bryan, M., Newcomb, S.: ISO/IEC13250:2000 Topic Maps: Information Technology, www.y12.doe.gov/sgml/sc34/document/0129.pdf.

[5] Dicheva D., Dichev C.: Authoring Educational Topic Maps: Can We Make It Easier?, *Proceedings of 5th International Conference on Advanced Learning Technologies, ICALT'2005*, Kaohsiung, Taiwan (2005) (to appear).

[6] Dichev C., Dicheva D. (2005). Contexts as Abstraction of Grouping, *Proceedings of Workshop on Contexts and Ontologies*, *12th National Conference on Artificial Intelligence, AAAI 2005*, July 9-13, 2005, Pittsburgh, Pennsylvania (to appear).