Contexts in Educational Topic Maps

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Abstract. This paper explores the idea of using contexts to support more efficient information search in Topic Maps-based digital libraries. The notion of context is perceived as abstraction of grouping of domain concepts and resources based on the existing semantic relationships between them. The proposed model of context is used for context representation in the TM4L environment.

Introduction

There is a large amount of high quality learning resources on the web already and they should be made more accessible to users. In this paper we explore the idea of using *contexts* to support more efficient information search. We propose to define contexts as abstraction of clusters of domain concepts and resources based on the existing relationships between them. This is related to our previous work on contexts as well as the development of a framework of concept-based digital course libraries [1]. The framework is based on using the new Semantic Web technology Topic Maps (TM) [2] that enables users to navigate and access documents in an organized manner.

In the topic map paradigm the *scope* feature defines the extent of validity of an assertion: the context in which a topic name or an occurrence is assigned to a given topic, or in which topics are related through associations. Thus thinking of representing contexts in TM, a quick straightforward answer would be to use the topic maps *scoping*. In the TM standard a *scope* is a set of *themes (of validity)*. Themes can be defined and applied to objects (topic names, resources, and associations). Obviously a scope can be used to present a context however this would be a rather static view. Independently of the standard we propose using TM associations to represent *context as grouping*. Topic maps associations can be interpreted as statements relating topics. For instance, in the case of educational applications, it is possible to express the statement that a given concept is represented in a particular learning object (e.g. *tutorial, definition,* etc.) in the form: topic X *is represented by* tutorial Y (in a particular syntactic form). Similarly, associations such as Prolog *is based on* Resolution, Prolog *refers to* Horn-Clause Logic, Prolog *applies* Backtracking, make the topic Prolog pertinent to the related topics. Obviously, association types combined with role types enable meaningful grouping of topics that we call *context.*

Formally context can be defined as a collection of statements that are true in a model. In a less formal perspective, context can be interpreted as the things, which surround, and give meaning to something else. The statement “Snow is white” is meaningful if we talk about New Year in Alaska, but has no meaning in terms of CPU scheduling. We can view contexts as a means of grouping facts relevant to a particular situation. Grouping and classification of objects is a human invention to simplify communication. For our purpose we take a restricted model of this view of context, namely, as a grouping of topics based on their relations to a given topic. Translated in TM terminology a context can be defined as a collection of associations related to a common topic selected to represent and name the context. Technically, this is a nested TM drawn around a topic chosen to name the context.

1. Context as grouping

Most works related to formalizing context are centered around the so called "box model", where "Each box has its own laws and draws a sort of boundary between what is *in* and *out*" [3], [4]. The problem with this approach is that we have to predefine all potentially needed "boxes" in order to use them. The world is too unpredictable to foresee the complete set of contexts that might be needed. Rather than preparing a set of static boxes we suggest to use a TM model that allows shifting boundaries of the context dynamically based on the current topic. The proposed interpretation of context as a collection of topics surrounding a given topic (denoting the context) is intended to localize the search and the inference within an area of *relevant* topics. It allows us to introduce a measure of relevancy. The interpretation of what are the surrounding topics is relative. At one point a topic can be part of the surrounding collection and at another point it can be viewed as surrounded by some other topics giving meaning to it. The relationships are at the heart of semantics, lending meaning to concepts and resources linked to them.

The basic assumptions underlying the proposed contextual framework include:

- Each context is a collection of topics related to a certain topic of the topic map that plays a role of a *focus or center* of the context.
- The central topic is unique and can be used to name the context.
- All semantically related topics identify regions formed by the topics directly or indirectly related to the center of the context.
- The relevance of a topic to the current context is reverse proportional to its distance to the focus of the context.

According to the last assumption the topics of a collection forming a context have no equal status with respect to that context. Their role in the context depends on the *distance* to the central topic. For each topic, the context maps that topic to a collection of topics whose degree of membership to the context depends on their level of relevancy. Among the valuable features of this context model is that it provides a mechanism to refer to the *current context*, and use it to identify an area of interest within the TM. This implies that searching for relevant information can be localized into a specified area of interest.

2. Context: minimal set of generic relations

Learning content typically embodies related topics, hard to be presented into conventional hierarchical structures. Thus we focus on a model for expressing a broader class of relationships on contextual structures. Our idea was to define *a minimal set of generic relations* which cover the needs of the intended applications. The advantage of such an approach is that generic relations subsume particular instances that might be impossible to articulate in specific terms. Our proposed minimal set of generic relations appropriate for e-learning applications is based on guiding principles including: (1) *Simplicity*: simpler is better other things being equal, and (2) *Scope:* a broader scope is better because it subsumes the narrower ones. We propose the following relations:

- *Part-whole* – a transitive relation that characterizes the compositional structure of an object. It is intended to capture in generic sense structural information that subsumes transitive relations of the type X is *part-of* Y, X is *member-of* Y, X is *portion-of* Y, X is *area-of* Y, X is *feature-of* Y, etc.
- *Relevant-to* - represents a family of asymmetric not necessary transitive relations. It is intended to capture in a generic sense asymmetric relations of the type X is *related-to* Y, X is *used-by* Y, X *refers-to* Y, X *points-out-to* Y etc.

- *Similar-to* - describes relations with symmetric roles assigned to the two role players. It is intended to capture in a generic sense symmetric relations of the type "co-refers" (X *is analogous-to* Y, X *co-mentions* Y, X *is-of-the-complexity-level-of* Y, X *is compatible-with* Y, X *is-matching* Y).

We extend this set with the conventional *superclass-subclass*, and *class-instance* relations. The basic intuition is that the five relations *superclass-subclass, class-instance, part-whole, relevant-to* and *similar-to* represent a sufficient basis of generic relations for e-learning applications. They can be used as a generic grouping of concepts and resources that might be difficult to articulate.

The proposed set of relations provides also a strategy for organizing the information. It supports a shared way of grouping topics by standardizing the used set of relations. The intended application of context in our framework includes the following aspects:

- Identifying an area of interest for more reliable and accurate interpretation of search requests.
- Providing a method for ranking the search results by relevance.
- Providing a framework for topic map visualization.

Context has the potential for enhancing the focus and precision of the search. Situating topics contextually provides additional information derivable from the distance between topics. Thus, search results can be listed with decreasing relevance to the search topics.

4. Conclusion

Efficient information retrieval requires information filtering and search adaptation to the user's current needs, interests, knowledge level, etc. The notion of context is very relevant to this issue. In this paper we propose an approach to context modeling and use in topic maps-based educational applications. It is based on the standard Topic Maps support for associations and defines the context as an abstraction of *grouping related information.* This context model provides a mechanism for referring to the *current context*, and using it to identify a current area of interest within the topic map. The latter is useful for localizing a search for relevant information within the current area of interest. We have used the proposed model of context in the design of TM4L, an e-learning environment aimed at supporting the development of efficiently searchable, reusable, and interchangeable discipline-specific repositories of learning objects on the Web [5].

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