

Modeling Personal Knowledge Networks to Support Resource Based Learning

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Abstract: In resource based learning settings learners have to cope with a multitude of resources. One big challenge for learners is managing the knowledge contained in these resources appropriately. We discuss some existing knowledge modeling methods and related tools with regard to learning scenarios. This paper focuses on presenting a knowledge modeling approach based on personal knowledge networks. Aggregation and mapping of these personal networks can form a community network supporting exchange of knowledge. Furthermore a proof-of-concept is described.

Keywords: Resource based learning, Knowledge networks, Knowledge representation

Categories: L.1.0, L.3.0, M.4, M.5

1 Introduction

For introducing resource based learning, we would like to start off with a typical personal learning scenario: Anne has to prepare a talk about the weather phenomenon wind. She doesn't know anybody to ask for help. Therefore she searches the web for information. She finds many web pages about this topic which can be relevant for her talk: news pages about catastrophes, scientific articles, weblogs with eye-witness accounts, reviews of books and many more. With one author of a paper she is familiar because she met him on a workshop in Berlin recently. He is an expert on this field and has published numerous articles about storm cycles. During her research she finds references to different kinds of wind like hurricane, blizzard and tornado and how they emerge. Besides the URL of these different web pages she wants to note a short summary and a hint about the reliability of the sources.

This small scenario is a typical informal learning scenario in resource based learning settings. Usually, this kind of learning is a self-directed learning process where learners have to cope with a multitude of information autonomously. We focus on supporting resource based learning on the web because the web is becoming more and more an important source for information as it provides easy access to up-to-date information. In the following parts, we subsume all web contents that can be accessed via web browser under the term *resource*. Challenges for learners are that all information on the web is widely dispersed and resources are not intended primarily for learning purposes. So, learners often suffer from conceptual and structural disorientation because of the huge amount of resources and the lack of structure between the resources. Moreover, resource management is an additional cognitive load. In this paper we focus on three goals:

One main goal of our work is the support of personal knowledge management: Resources shall be organized in a form which supports efficient and effective retrieval of resources even after a long time. Often people forget the exact title or the author of a resource. But they can remember context information, for example the fact that the author is an expert of a special field or that the resource was found during a particular task. Therefore learners should be enabled to save not only the resource but also specific information which has only indirect relations to the resource but is important for the learners. This means that learners should be supported to externalize their knowledge into an information system based on their own needs.

A second main goal is the integration of knowledge in the own knowledge structure: Learning is efficient especially when the learners are active [Meier, 06]. The classification of new resources in the own knowledge structure is such an active process. While saving new resources, associations between already saved resources and topics have to be analyzed by the learners. Thus, new knowledge is connected to existing knowledge. At the start of a research, learners search for resources about a broad overview of a topic if they are novices in this topic. Later they are able to identify subtopics and more specific terminology and thus can search for resources in a more systematic way. They will find new connections between known topics. By modeling these links, an interlaced knowledge structure is created. As interconnecting knowledge, topics and information in such a way, islands of knowledge are avoided.

The third goal is supporting communication of knowledge. Learning is a social process [Cross, 06]. Most learning takes place through communication and during community activities like collaborative work on a project. Building networks between people and content is important especially in the unstructured processes of informal learning. Therefore we develop an approach that enables learners to model their knowledge individually, but still with the possibility to share their knowledge and to profit from other learners.

Some approaches to model knowledge structures and related tools are discussed in the next chapter. In [chapter 3], the modeling of the proposed personal knowledge networks is described. A prototype as proof-of-concept is shown in [chapter 4]. Finally, this paper concludes with a summary and further steps in [chapter 5].

2 Related Work

Representations of knowledge can be modeled using knowledge modeling techniques. They aim to represent knowledge in information systems based on concepts and relations. Knowledge is coded into a form that is interpretable by a computer for processing the modeled knowledge and reasoning with it [Stock, 08]. However, the resource-based learning scenario has special requirements because learners are no experts in knowledge modeling. Therefore, an adequate knowledge modeling technique has to be individual, flexible and easy to use. In the following sections, three knowledge modeling methods (ontologies, topic maps and semantic networks) and respective example systems are described and evaluated with regard to their possible use in resource based learning. Further, we discuss the tagging concept and social tagging systems, although it is arguable if they can be categorized in one of the knowledge representation methods.

2.1 Ontologies

[Studer, 98] defines ontology “as a formal, explicit specification of a shared conceptualization”. This is a definition from information science that extends the familiar definition of [Gruber, 93]. Building and designing ontologies is a formal process with a focus on collaboratively classifying concepts and creating associations (e.g. subtopic relations). This usually involves intensive discussions about concept definitions. Axioms and logical rules can be defined in ontologies. Axioms are declarations that are always true and are neither contained in the ontology nor can be reasoned with it.

Semantic Desktops are systems that build individual knowledge representations based on (personal) information management ontologies. These applications aim to support users in organizing, finding, creating and communicating knowledge [Sauer mann, 09]. Therefore they model resources like e-mails, calendar dates, address information, locations, desktop files, web artifacts, etc. that are typically present in information management scenarios and append (automatically extracted) metadata to these resources. Nepomuk [1] is one relevant example for Semantic Desktop applications that aims to exchange information over boundaries of applications and desktops. Further, it provides collaborative content production tools like a semantic wiki to enable users to communicate knowledge over a network of people.

Semantic Desktops use ontologies with fixed rules. Thus, extending and adapting personal ontologies to new contexts requires a high level of expertise in modeling ontologies. Finally, Semantic Desktops are not designed for learning contexts but for personal information management of rather structured information.

2.2 Topic Maps

Topic Maps (an ISO standard) consist in essence of topics, scopes, associations and occurrences which link topics with external information resources.

Digital Mapping Tools like Ontopia Knowledge Suite [2] serve as knowledge repositories and as navigational tools for digital environments modeled as Topic Maps. They represent conceptual knowledge, content knowledge and related information [Tergan, 05]. Because of their visualization, they give a good overview of content structures and can show relations between concepts or knowledge gaps, as well.

Although digital mapping tools are applicable for knowledge communication, they do not support social collaboration for building communities. Big maps without an added explanation are difficult to understand for other learners because they become crowded and/or complex if much content is included.

2.3 Semantic Networks

[Sowa, 92] defines semantic networks as “graphical notation for representing knowledge in patterns of interconnected nodes and arcs”. This idea goes back to [Quillian, 68], who strived for a more comprehensive representation of meanings of words in thesauri. He distinguished between *types* and *tokens*. In his terminology,

[1] <http://nepomuk.semanticdesktop.org/xwiki/bin/view/Main1/> Online: 2009/03/03

[2] <http://www.ontopia.net> Online: 2009/03/04

types are classes of concepts and tokens are instances of types, e.g. Anne is a token of the type *person*. This distinction is not necessarily required because the differences between types and tokens can also be modeled with specific attributes [Huijsen, 04]. Usually, in semantic networks nodes are interpreted as concepts, edges as relations, and both may be labeled for specifying their types.

The *Semantic Web* [Berners-Lee, 01] is not a single application but it subsumes knowledge technologies that aim to provide background and context information to web resources so that computers are able to process and infer over their actual content. They add a semantic layer to web contents in order to bridge the knowledge gap between human beings and computer machines.

By adding descriptions of content, context and structure to web resources a flexible and personalized access can be provided so that resources, which were not intended for learning purposes, could become learning materials. For example, a teacher could add additional information like covered topics, required previous knowledge, target group, etc. with which students can be guided. A disadvantage of semantic web technologies is that modeling a semantic network is often as complex as building an ontology.

2.4 Tagging

Tagging is a paradigm by which users add arbitrary keywords to items, be it websites, books or friends. As web 2.0 applications are emerging, tagging becomes more and more important as a simple means for users to organize their items in without the constraints imposed by strict hierarchical organization (e.g. having to choose a unique category for items). By aggregating the tags of all users, folksonomic structures emerge that all users can profit from. Either the tags are predefined in a vocabulary or they can be chosen freely.

There are several web-based annotation systems with social-network features. Delicious [1] - a free *social tagging application* - enables users to save, annotate, manage and share web pages. It is described here exemplarily with regard to tagging features because tagging can lead to a knowledge structure. On saving a resource, the system suggests tags, e.g. on the basis of a combination of tags of the user and of the folksonomic structure. The own resource collection or the web pages of other users can be browsed via tags. It is possible to build up networks with other users and to share the collection with them.

Tagging is a very easy and flexible way to organize knowledge, but in existing tagging tools only relations between resources and tags are possible. Linking and structuring tags in an explicit way has not yet been realized, except features like the trivial "bundling" of tags as used in Delicious.

2.5 Conclusion

The different forms of knowledge representation mentioned above are often used synonymously in scientific works, e.g. sometimes ontologies are defined as a special case of semantic networks or vice versa. All structures can be represented graphically as a network consisting of nodes and edges. For end users, differences between the

[1] <http://www.del.icio.us> Online: 2009/03/03

forms of knowledge representation are insignificant [Steinacker, 02]. The different forms can be transformed into each other, but some meaning can be lost due to the different strengths of modeling methods.

3 Modeling Knowledge Networks

In our scenario of resource based learning, users model their knowledge structure individually. These users are novices in knowledge modeling, thus the task of creating knowledge representations via formal modeling methods is too complex and takes too much time to learn. Therefore we propose an approach based on a combination of semantic networks and the tagging concept. We use the term *knowledge network* in this paper to distinguish from formal modeling methods.

In the following, some terms are explained for a better understanding of the next sections in this chapter. We differentiate between *concepts* and *individuals*. In analogy to object oriented software engineering, *concepts* correspond to *classes* and *individuals* to *instances*. Concepts define possible attributes of an individual e.g. URL is such an attribute for an individual like a resource in our scenario. The attribute definitions as a whole are called attribute schemas. User defined attribute schemas are named *extensions* (as – again analogue to object oriented programming – the concepts themselves are extended to provide additional attributes). Links between resources and concepts and among each other are called *relations*.

In essence, personal knowledge networks in our scenario consist of resources, tags and relations between them. Resources and tags are nodes in the network with predefined attributes, e.g. all individuals have an internal id, a name, a date of creation and a date of last update. The *resource concept* defines the attribute schema for all *resource individuals*. In our model, a resource can have the additional attributes *URL*, *description* and *screenshot*.

Tags are only identified by an id and a name. They are comparable to tags in other tagging systems as they represent a simple plain-text token and have no further attributes. Besides simple tags there are further special tag types: *topic*, *person*, *goal*, *event*, *location* and *miscellaneous*. Users can model their own attribute schemas as extensions for these specialized tags. As these definitions are abstract, an example based on the scenario of the [1 Introduction] in the next section will clarify this.

3.1 Focusing on Modeling Personal Knowledge Networks

Anne, the learner in the scenario of the [1 Introduction], wants to manage resources she found together with additional information in her personal knowledge network. Therefore she saves the resources with their properties *URL*, *name* and *a description of the web page*. How we support this process of saving resources in our software will be described in [chapter 4].

In the knowledge network all resources are saved as individuals of the *resource type* and the properties are saved as the individuals' attributes. Anne has found all the resources in this scenario in the context of her goal preparing a *talk for the seminar climatology* dealing with the topic *wind*. This goal is an important possibility for Anne to structure and to organize her found resources. Later she is able to retrieve these resources via this goal if she links all resources with this goal. The linking can

be done easily by tagging with the name of the goal *talk for the seminar climatology* when saving the resource. When tagging, Anne can assign a specified tag type to this keyword. If she specifies *talk for the seminar climatology* as goal, this tag is created as individual of the *goal type* and the relation between resource and goal is drawn automatically. If the tag has already existed in her knowledge network, only the relation is created. Anne saves also the association between the goal *talk for the seminar climatology* and the topic *wind*. Therefore Anne tags the goal with *wind* and specifies it as *topic type*. Similarly, Anne creates a relation between a resource and *Prof. Meier* (person type) who is related to a *workshop* (event type) which is again linked with *Berlin* (location type). The information *eye-witness account* is important for Anne because therewith she can vitalize her rather theory-centric talk. She tags the corresponding resources with the keyword *eye-witness account* without assigning a specified tag type. If required, Anne will catch up on specifying it later.

The predefined types and attributes in the basic model are not sufficient for Anne to be able to model all desired information in her knowledge structure. The resources, which Anne collects during her research, represent different information types. Therefore she creates a new *scientific article type* which extends the existing *resource type*. For individuals of the scientific article type she defines an attribute *year of publication*. She does this with the extension *book type* in the same way. For individuals of *book type* she can save the ISBN now. Thus, Anne can sort her resources e.g. with regard to the information type, for example if she only wants to get all scientific articles. This example shows that a flexible and easy, yet exact, modeling of an own knowledge structure is possible by using tags and specifying extensions. Especially the possibility of specifying the tag type due to personal preferences is useful for modeling the network, as users will find it easier to retrieve the information later as stated in our first main goal: Users may save resources with relevant additional information in order to externalize their knowledge structure similarly to the knowledge structure in their mind, having the possibility to extend the existing structure if required.

3.2 The Aspect of an Aggregated Community Knowledge Network

All personal knowledge networks are managed in the same data base, thus all knowledge networks can be accessed centrally. All individuals, extensions and relations that are modeled by each user are linked to the respective user automatically in order to ensure the separation of the user's and the other users' networks. This makes building a community knowledge network by aggregating and mapping of all available personal knowledge networks possible. For example, identical tag names or URLs of resources allow automatic conclusions that there are similarities or overlaps between different personal knowledge networks. Thus, automatic mappings enable users to share their knowledge structures without prohibiting to model their structures individually. Further, users can be made aware of each other and profit from resources of other users, which can be recommended for the current research.

Still, mapping of knowledge networks poses several challenges like usage of different names for the same things and vice versa. In future work, we will improve existing algorithms for identifying similarities and differences between knowledge structures and adopt them to personal knowledge networks.

4 Prototype

We implemented a prototype (see [Fig. 1]) as a proof-of-concept that is composed of three parts: a backend for storing and managing the knowledge networks, a client that represents the GUI to the user and a web service that handles the exchange of data between backend and client. The backend is based on K-Infinity [1] to which the web service provides a thin layer; both are not a focus of this paper.

The client is embedded as a sidebar into the web browser Firefox. When importing a web page into the knowledge network, the client extracts URL, title and marked text of the imported web page and creates a screenshot for visual orientation and quick re-finding. Users may alter this automatically extracted information and additionally tag the resource. The prototype shows already existing tags via auto-completion and tag clouds. Tags that exist in the community network but not in the user's one are marked. Assigning specific tag types is simply done by entering the tag name into a text field corresponding to the respective type. For extending the predefined types there is a form where users can type the name of the new extension and define its attributes.

While searching for new information on the web, the client presents additional information when a new web page is opened in the browser. For example, users are notified if the current web page has already been saved in their own knowledge network. If this is the case, resources with similar tags to the current page are shown, so that users can get a quick overview of the resource's context in the knowledge network. Similarly, users are notified if another user has saved this web page and further probably relevant resources are listed. The shown resources in the sidebar are potential starting points for further browsing the knowledge network.

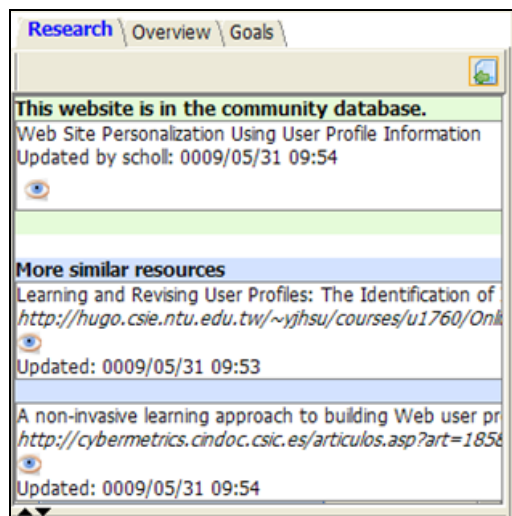


Figure 1: Similarly tagged resources to the current page in the Firefox client

[1] <http://i-views.de/> Online: 2009/03/03

5 Summary and Next Steps

This paper describes a knowledge modeling approach based on personal knowledge networks to support knowledge management in resource based learning. It combines the advantages of tagging and semantic networks (by the concept of specifying tags) and allows knowledge management that matches the users' way of thinking by using tags from any type and the possibility to define own extensions. A first short-time evaluation shows that the particularities of resource based learning are accounted for. At the moment, we are evaluating this prototype in a complex user study with a group of PhD students over a period of four weeks to get feedback on how to improve our concept. In future work, we will address mapping algorithms in order to improve collaboration of users and recommendation of similar relevant resources.

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