

ReCredible: Topic Maps for Knowledge Management and E-learning

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ABSTRACT

Topic Map technology (ISO 13250) is a way to facilitate the management and navigation of knowledge by creating meta-level perspectives of the underlying concepts, and the relationships between concepts that are expressed by domain ontologies. Topic maps are known to be an effective tool for organizing and navigating information, and for integrating different kinds of knowledge resources. In addition, Topic Map technology can become the core of an e-learning portal that will allow users to explore and navigate datasets through faceted searches and graph browsing, to discover related information and to understand concepts and their relationships better than using traditional reading of continuous texts. This paper discusses the need for an innovative virtual study environment. The focus is on our work on the development of the innovative platform, 'ReCredible' that will allow users to find information quickly and to learn more easily using Topic Maps.

Categories and Subject Descriptors

D.2.2 [Software Engineering]: Design Tools and Techniques - user interfaces,

I.2.4 [Ontologies],

I.2.7 [Artificial Intelligence]: Natural Language Processing,

H.3.4 [Semantic Web],

K.3.1 [Computers and Education]: Computer Uses in Education

General Terms

Algorithms, Management, Measurement, Design, Standardization, Languages, Theory, Verification.

Keywords

Topic Map, concept map, ontology, e-learning, e-learning platform

1. INTRODUCTION

Fascinating technological advances and an overwhelming amount of information even within specific topics has prompted the growth of new technologies for knowledge management. Topic Map technology (ISO 13250) is known to be an effective tool for facilitating the management and navigation of information. The core of topic maps can be summarized very succinctly: a topic map consists of a collection of *topics*, each of which represents some concept. Topics are related to each other by *associations*. A topic may also be related to any number of resources by its *occurrences*. The definition of allowed types is known as the ontology of the topic map. Topic Maps are similar to concept maps and mind maps in many respects, though only Topic Maps are standardized.

We describe a novel solution in our ontology-driven Topic Map portal 'ReCredible' that interlinks concepts, definitions, related information and online resources via semantic, related Topic Maps. Our basic idea is to convert unstructured information to lightweight ontologies that are optimized for visual browsing,

content discovery and curation, and to use this for educational purposes. This idea has been stimulated by the theories described below.

2. MOTIVATION OF THE SOLUTION

Meaningful learning theory says that learners must relate new knowledge to relevant concepts they already know [1]. Meaningful learning involves recognition of the links between concepts. According to Ausubel [1], knowledge is hierarchically organized, so we learn by constructing a network of concepts and adding to them. The concept map, developed by Novak's research group at Cornell University in the early 1970s, is an instructional device that uses this aspect of theory to find a better way to represent conceptual understandings [2]. Novak found that the use of concept maps could help students *learn how to learn meaningfully* [2].

According to Novak et al. [3], advances in graphical user interfaces and technologies in the 1990s allowed for the development of computer-based concept mapping editors. The development of concept mapping tools such as CmapTools [4] enabled the collaborative construction of concept maps, and publishing and sharing of concept maps on the Web [3].

During the last decade concept mapping has been applied to teaching and learning of different subjects and courses, including medicine [5], [6], physics [7], [8], [9], biology [10], [11], chemistry [12], [13], business and management [14], mathematics [15], social studies [16], [17], learning foreign languages [18], [19], etc. Concept mapping has been shown to be effective when used as an assessment tool at all levels of education. When used with pre-school or elementary school children, concept maps also facilitate language learning and learning to read as well as promoting better ways to learn [3]. It is clear that concept mapping has had a large impact on facilitating easy understanding of the subject to be learned, and on the organization of the learning content. In addition, concept maps have been identified as an effective tool for evaluation, displaying students' prior knowledge, summarizing what has been learned, note taking, aiding study, planning, scaffolding for understanding, consolidating educational experiences, improving affective conditions for learning, teaching critical thinking and supporting cooperation and collaboration [20].

Despite the fact that concept map technology is an effective tool for the learning process, it is not used universally. Although texts, videos, pictures, presentation slides and other forms of material representation are used every day in learning activities, concept maps are not so popular. The most important reason is that constructing concept maps is not easy – it requires effort and time to build a good map. Concept mapping or mind mapping tools are not simple to use. Specialists or domain experts create domain ontologies, but this is done with sophisticated software and is therefore not a feasible method for the ordinary user. There is a lack of the tools needed for constructing concept maps that are both easy to use and don't rely on some knowledge of the underlying theory. In addition, there are no mobile applications

or online courses on the web that would provide learning material in the form of the concept maps or would incorporate the concept maps in e-learning content. For these reasons we have used Topic Maps, which are a standardized means of representing polymorph structures in a comprehensive way for building an innovative e-learning tool for knowledge management and e-learning.

3. DESCRIPTION OF THE SOLUTION

As mentioned above, ReCredible.com beta (along with the ReCredible mobile applications for iPad and iPhone devices) is a personal learning environment based on the concept of topic maps. This section discusses this powerful way to manage, structure and navigate knowledge, and describes the use of the intuitive, visual interface of the ReCredible system for learning purposes. We offer a new methodology for the development and maintenance of the Topic Maps e-learning portal and briefly present a pilot application.

3.1 Focus of ReCredible

In virtual study environments, Topic Maps technology is applicable as follows. Each e-course focuses on a certain discipline, which has its own terminology. This terminology is conceptualized by the discipline (domain) ontology. The Topic Map application of study resources can be built above this ontology. Such a Topic Map application visualizes the discipline terminology, which helps students to understand the structures of studied disciplines [21]. In addition, together with the discipline ontologies, used for subject categorization of resources, it is possible to apply a kind of course ontology for arranging units and elements that together form the course content. Therefore teachers can define the recommended order of resources (presentations, documents, exercises etc.) to be studied using the Topic Map portal, as well as in the e-course's study content module in the current virtual study environments [21].

The ReCredible system focuses on the development of topic maps for e-learning content but it offers opportunities to integrate different kind of e-learning resources (e-courses material, videos, presentations, exercises, and links to online courses) as well. Currently, ReCredible beta users can browse Topic Maps for different content and search for information. Tools for different resources integration are being developed and will be available soon.

All the concepts, definitions, related information and online resources are interlinked via semantic, related concept maps in ReCredible. Topic Maps technology allows users to find information quickly without reading all the text, and to memorize it easily, looking at the knowledge as a whole. ReCredible could become the way that people explore and learn about topics and concepts, enjoying easy navigation and a visual experience. The ReCredible system provides an alternative to traditional learning methods and reading of continuous texts. This will become increasingly important in the era of touch screens, smart glasses, and motion sensing. In addition, the use of Topic Map technology will allow the application to assess the user's interests and knowledge automatically based on his search in the ReCredible concept maps, and to offer the most useful topics and concepts to the user, as well as related online resources which would be interesting for him. Unlike other e-learning courses or tools, ReCredible assesses the user's interests in just a few seconds because of the use of Topic Maps where all the knowledge is interlinked.

ReCredible converts unstructured information to lightweight ontologies that are optimized for visual browsing, content discovery and curation. We are basically trying to democratize

ontology creation so every user of ReCredible can take part in the creation of the Topic Maps and e-learning material. Registered user can edit Topic Maps, add information, and create new Topic Maps in very simple and intuitive way. Educational institutions will receive APIs so that they can include plugins of ReCredible in their systems.

As has been described above, the main idea of ReCredible is to provide a Topic Map based system for knowledge finding and e-learning. This idea has several advantages.

1. The concept map of the knowledge. These days mankind creates and stores more information in a single day than was created and stored in previous centuries. It is paradoxical, but people are reading less and less, and finding it harder to work out which parts are most important for them in the mass of information. The information given in ReCredible is linked via Topic Maps in the same way your mind links concepts, allowing the user to find the exact information very quickly without reading different texts.

2. Personalization of learning process. The platform breaks learning into bite-sized chunks and offers each part as a "snack" so it is possible to choose your own way of reading concepts.

3. User-friendly, intuitive navigation enabled by ontologies. Typical e-learning tools or online courses consist of various information that includes texts, pictures and links, but a better way to understand and memorize information is graphic visualization. ReCredible converts unstructured information to simplified visualized ontologies that are optimized for visual browsing, content discovery and curation. The attractive visualization of Topic Maps helps users to memorize information very intuitively.

3.2 Development of ReCredible technology

Current Topic Map technology (ISO 13250) is on its way towards consolidating its position as a powerful way to manage structure and navigate knowledge. The general idea behind topic maps is to organize information by subjects and relations between subjects [22].

No methodology of Topic Map application creation is presented in the basic ISO/IEC Topic Map standard, so the consecution totally depends on authors of particular Topic Map applications and on software used for the implementation of Topic Maps applications. General Topic Map developers' guides suggest adopting either a top-down, or bottom-up methodology. The former works by defining the application area, and the second by summarizing the available information and knowledge resources to be covered by the Topic Map application [21].

In both approaches, the next Topic Map application development contains the following steps:

- definition of functional requirements and the purpose of the future Topic Map
- definition of schema of the Topic Maps based portal - the ontology
- selection of the tool for implementation of the Topic Maps solution
- population of instances, including evaluation of fulfilling all restrictions and constraints
- optional revision of the schema of the Topic Maps [21]

The Topic Map model defines three basic building blocks: topic, association and occurrence [23]. Topics are computer representations, either of particular subjects of our world, or abstract categories that exist in this world. Occurrences are characteristics of topics and are true in the context of the particular scope. The occurrence is a string value - either a statement about the topic, or a link to the resource (monograph, article, image, sound file etc.). Associations are essential for

establishing the network structure of topic. Two or more topics are in an association if there is some relationship between them. The solution developed on recredible.com includes the semi-automatic generation of Topic Maps and visualization of the generated Topic Maps. The entire system works on a client-server principle. The system proceeds according to three major steps: a) a topic is created using an online editor; b) the topic is converted into our topic map format and hosted on our servers; c) the topic is published and made accessible via a frontend of choice (visualized on a touchscreen or web-enabled frontend). These steps are illustrated in Figures 1 and 2.

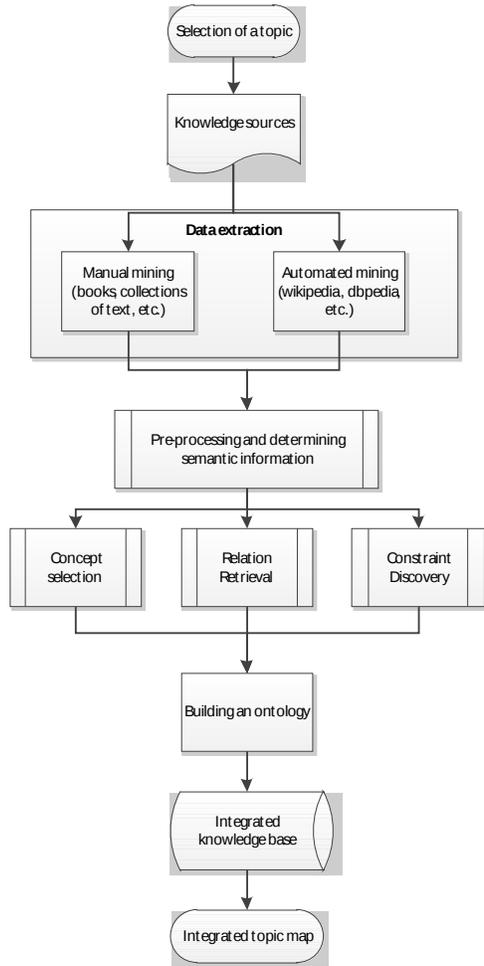


Fig. 1 Making a Topic Map

Figure 1 illustrates the simplified building of a Topic Map. Each Topic Map is chosen very carefully by determining which domain the ontology will cover, what we are going to use the ontology for, what types of answers the information should provide, and who will use the ontology. The process itself is started by data extraction from various sources. This is done either manually from books and text, or automatically from structured sources of information (such as Wikipedia, DBpedia, FreeBase, etc.). Developing an ontology includes defining classes in the ontology, arranging the classes in a taxonomic (subclass–superclass) hierarchy, defining slots, describing allowed values for these slots and filling in the values for slots for instances. Everything is saved and maintained in our knowledge base.

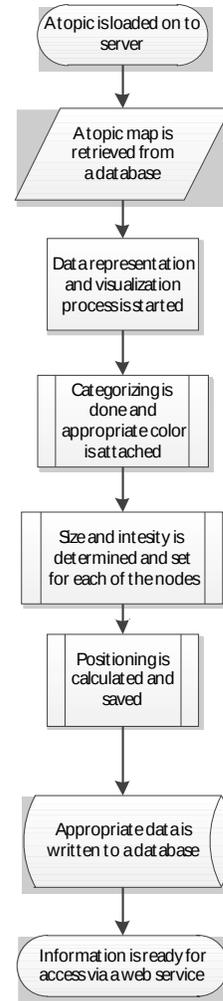


Fig. 2 Backend processing

3.3 Visualisation of ReCredible Topic Maps

Information visualization is a well-studied scientific topic, and unfortunately remains an unsolved problem. Since the earliest cave paintings, Homo Sapiens have always pursued an effective way to visualize information. Our knowledge perception systems and abilities are the result of evolution. Graphical perceptions are processed pre-attentively and rapidly, and are accessible intuitively without the need for active cognition. ReCredible visualization solution allows us to access, control, explore, combine and manipulate various types of knowledge, also helping us to create new insights. Knowledge visualization and visual thinking are gaining importance in all areas of science, e-business and society. Knowledge visualization aims to facilitate the mutual transfer of facts, insights, experiences, values, expectations, perspectives, opinions and predictions. State-of-the-art visual approaches aim to support the creation, application and communication of knowledge and insights – particularly in situations where people from different educational, cultural and professional backgrounds collaborate. This method of information display offers an easier way to dive into the data itself, much like a human brain works. The main problems are

effectively creating and transferring insights between various information sets, various users, and effectively various minds, as well as managing and reducing the complexity of standard presentations, thus allowing a more effective interpretation and understanding by such increasing the amount of parsed data, supporting learning, communication and interaction through novel and easier-to-grasp approaches and techniques. To ensure that visualizations can match the problem, purpose and knowledge in mind, new visualizations are often required to support various tasks.

Visualization of ontologies is not an easy task. Ontology is something more than a hierarchy of concepts. Relations among concepts and each concept have various attributes. We think that the following five questions should be answered in any good knowledge visualization model [24]:

- What is the aim and the effect of externalizing knowledge into visual representations?
- What is relevant and should be visualized?
- Which audience should be addressed?
- What is the interest of the recipient?
- What is the most efficient way to visualize the knowledge?

We have developed techniques specifically for visualization of our application. The backend of the system (see Figure 2) consists of the Mongo database, which is a NoSQL data structure well suited to storing nested data like Topic Maps.

For rapid server-client communication the RESTful Web service API (Application Programming Interface) was created. With the use of API, the client's application can easily receive detailed information about the Topic Maps and each individual topic. All the data is served in a JSON format. The process starts with retrieving a Topic Map from a database and starting a data representation and visualization processes. In principle what it does is check for a number of possible categories, assigning a visual representative for each of those (a different color), setting the opacity depending on the quality of content inside, determining the possible size and position of each node based on the relations they have, and writing all this information back to the database of visualization-ready Topic Maps. At this stage a web-service-ready Topic Map is generated. Data is "mixed and matched" to be as easy to understand as possible, and also as visually attractive as possible. The visualization method of ReCredible displays all the ontology classes at once or at the request of the user, providing their name in an intelligible manner using a specific color (see Image 1).

Image 1. A orbit view in ReCredible: pilot iPad application

As instances are the actual data associated with the ontology and are typically what most users are actually looking for, we represent them as connected nodes (bubbles). As showing all the connections via visual links is not effective when there is a large number of relations we have an overview mode (called orbit view) which presents instances in an orbit, where more important items are moved towards the center of the orbit (see Image 1).

The presentation of the taxonomy on which the ontology is based is essential for understanding the inheritance relations between classes, thus we provide a holistic view of this taxonomy. The user can hide certain items thus creating a partial view and focusing on a portion of the taxonomy. When a class has more than one parent the tree view (see Image 2, Image 3) presents an effective visualization to indicate nodes with multiple parents and provide efficient means to view all the direct ancestors of a node. Links (relations) are also displayed in the tree view but the names are hidden to avoid clutter, especially on smaller screens such as on an iPad. It's possible to display the names on a larger screen (e.g. recredible.com) or when the hierarchy is smaller and more manageable, and this is always an option to consider.

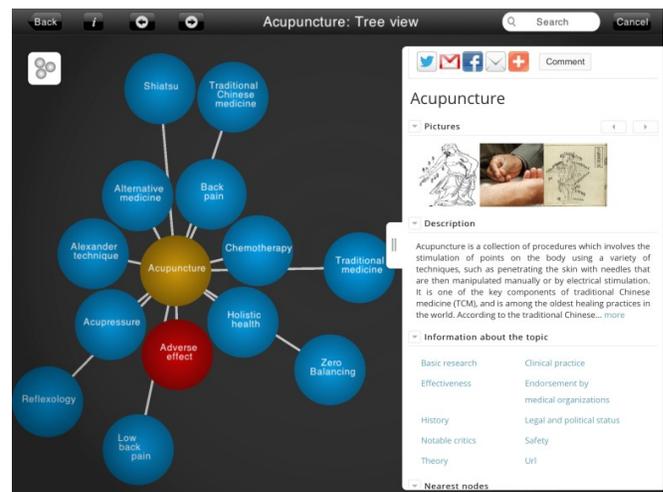


Image 2. The tree view in ReCredible: pilot iPad application



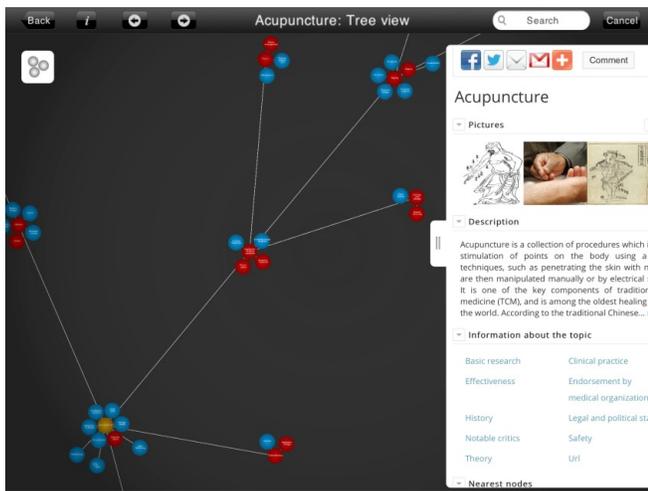


Image 3. An expanded tree view of ReCredible: pilot iPad application

We have implemented tree-based node link diagrams as they are considered among the most common and intuitive ways for hierarchy representations of semantic networks. This system offers an effective overview of semantic data structures of different levels and features. In our analysis of different models and methods, we concluded that methods such as cone tree implementations [25] are most suited to helping users answer structural and trend-related questions. Tree node – link methods [26] have the disadvantage of requiring a lot of screen space, but we have solved this via finger-friendly interactions.

Our test users have commented on the lack of interaction and had experienced problems with traditional navigation, such as having to drag the scrollbars to navigate or use zoom in and out commands, and sometimes clicking accidentally on an instance, which resulted in wrong class or object, or even a loss of focus. A ReCredible approach allowed us to overcome this in a much more intuitive way, allowing sorting (instances can be interactively sorted and color/size coded via types, categories, groups, etc.). Most of our users thought that the ReCredible system could be very effective for smaller ontologies or if the user is familiar with the ontology as it seemed to them useful for the presentation of hierarchies, even allowing them to return to a previously visited node and quickly jumping to hierarchy overview, because it maintains a constant positioning of the nodes in combination. Our nodes can be controlled by expansion of sub-trees, as expanding child up to a certain level, seemed to be very effective. As defined in [27] a task that included finding a specific node with the maximum number of connections to another type of node, users preferred to browse using the orderly tree types of knowledge rather than attempting to locate the node with the most connections.

4. CONCLUSIONS

In this paper we have proposed understanding virtual study environments as a kind of knowledge management system based on the Topic Maps standard. The ReCredible example described above illustrates the broad range of activities related to knowledge finding and curating, information creating and e-learning that are possible when using Topic Maps.

Graphical tools such as ReCredible Concept Maps enable anybody to express and interpret knowledge in a form that is easily understood.

5. REFERENCES

- [1] Ausubel, D. P. 2000. *The acquisition and retention of knowledge: a cognitive view*. Kluwer Academic Publishers.
- [2] Novak, J. D. and Gowin, D. B. 1984. *Learning How to Learn*. New York, NY: Cambridge University Press.
- [3] Novak J. D. and Cañas J. 2010. The Universality and Ubiquitousness of Concept Maps. In *Concept maps: Making Learning Meaningful. Proceedings of the fourth International Conference on Concept Mapping*, 1-14
- [4] Cañas A. J., Hill, G., Carff, R., Suri, N., Lott, J., Eskridge, T., et al. 2004. CmapTools: A Knowledge Modeling and Sharing Environment. In *Concept Maps: Theory, Methodology, Technology. Proceedings of the First International Conference on Concept Mapping* vol. I, 125-133. Pamplona, Spain: Universidad Pública de Navarra.
- [5] Daley, B. 2002. Facilitating Learning with Adult Students through Concept Mapping. In *The Journal of Continuing Higher Education* 50(1), 21-31.
- [6] Daley, B. J. and Torrem D. M. 2010. Concept Maps in medical education: an analytical literature review. In *Med Educ.* 44(5), 440-8.
- [7] Pérez A. L. R., López M. I. S, Montanero-Fernández M., Fernández P. J. P., Montanero-Morán M. 2010. Concept Maps and Conceptual Change in Physics. In *Handbook of Research on Collaborative Learning Using Concept Mapping*.
- [8] Martínez, G., Pérez, A. L., Suero, M. I., Pardo, P. J., 2013. The Effectiveness of Concept Maps in Teaching Physics Concepts Applied to Engineering Education: Experimental Comparison of the Amount of Learning Achieved With and Without Concept Maps. In *Journal of Science Education and Technology* vol. 22, issue 2, 204-214.
- [9] Nousiainen, M. and Koponen, I. T. 2010. Concept maps representing knowledge of physics: Connecting structure and content in the context of electricity and magnetism. In *NorDiNa* vol 6, no 2.
- [10] Fisher, K. M., Wandersee, J. H., Moody, D. E. 2001. *Mapping biology knowledge*. Kluwer academic publishers.
- [11] Trifone, J. D. 2006. To What Extent can Concept Mapping Motivate Students to Take a More Meaningful Approach to Learning Biology? In *The Science Education Review*, 5(4), 121-123.
- [12] Schanze, S. and Grüß-Niehaus, T. 2008. Supporting comprehension in chemistry education - the effect of computer generated and progressive concept mapping. In *Paper presented at the Third International Conference on Concept Mapping (Concept Mapping: Connecting Educators)*, Tallin, Estonia & Helsinki, Finland.
- [13] Grüß-Niehaus, T., Hundertmark S., Schanze, S. 2009. proCMap – Computerbasiertes progressives Concept Mapping. *Chemie- und Physikdidaktik für die Lehramtsausbildung*, 253-255.
- [14] Frisendal, T. 2012. *Design Thinking Business Analysis. Business concept mapping applied*. Springer.
- [15] Afamasaga-Fuatai', I. K. 2009. *Concept mapping in mathematics*. Springer.
- [16] Macceca, C. 2007. *Reading Strategies for Social Studies*. Shell Education.

- [17] Alansari, W. M.. 2010. *Use of Concept Maps to Improve Saudi Pre-service Teachers' Knowledge and Perception of Teaching Social Studies*.
- [18] Lee, Y. 2010. *Concept mapping strategy to facilitate foreign language writing: A Korean application*. http://surface.syr.edu/tl_etd/229
- [19] Tuan, L. and Thuan, L. 2011. The Linkages between Concept Maps and Language Learning. In *Studies in Literature and Language* Vol. 2, No. 1, 128-146.
- [20] Coffey, J. W., Cañas, A. J., Reichherzer, T., Hill, G. A., Suri, N., Carff, R., et al. 2003. Knowledge Modeling and the Creation of El-Tech: A Performance Support System for Electronic Technicians. In *Expert Systems with Applications*, 25(4), 483-492.
- [21] Olsevicova, K. 2006. Topic Maps e-Learning Portal Development. In *Electronic Journal of e-Learning*, vol. 4 Issue 1, 59-66.
- [22] Lavik, S., Nordeng, T. W., Meløy, J. R., Hoel, T. 2007. Remote Topic Maps in Learning. In *Leveraging the Semantics of Topic Maps. Lecture Notes in Computer Science*, Vol. 4438, 67-73.
- [23] Pepper, S. *The TAO of topic maps*. <http://www.ontopia.net/topicmaps/materials/tao.html>
- [24] Burkard, R. A., Meier, M., Rodgers, P., Smis, M. T. J., Stott, J. 2005. Knowledge visualization: A comparative study between project tube maps and gantt charts. In *Proceedings of I-KNOW 05*, Graz, Austria.
- [25] Carriere, J.,Kazman, R. 1995. Interacting with huge hierarchies: beyond cone trees. In *Proceedings of Infoviz'95, iee Symposium on Information Visualization*, Atlanta, Georgia, 74-7.
- [26] Plaisant, C., Grosjean, J., Bederson, B. B. 2002. Spacetree: supporting exploration in large node link tree, design evolution and empirical evaluation. In *Proceedings of iee Symposium on Information Visualization*, Boston, 57-64.
- [27] Lee, B. Parr, C., Plaisant, C., Bederson, B.B., Veskler, V.D., Gray, W. D., Kotfila, C. 2006. TreePlus: Interactive Exploraton of Networks with Enhanced Tree Layouts. In *IEEE TVCG Special Issue on Visual Analytics*.