Multi-context based browsing in Heterogeneous Semantic Spaces: The Ontology Switching Approach

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Abstract. Homogenization has been the most widely applied approach to create common semantic spaces when it is necessary to overcome the limitations of sharing knowledge posed by semantically heterogeneous concept structures. Ontology switching manages diverse ontologies by integrating them and enables the user to access them in parallel. Most important, the user can change his point of view by switching to another concept structure at any point and explore different viewpoints according to his current context. An ontology switching system dynamically reorganizes the concept structure and populates it with knowledge objects. The paper describes the design options for ontology switching systems, presents prototypes, evaluation results and points to future developments. This work integrates research on the semantic web and on human-computer interaction.

1 From Semantic Heterogeneity to Ontology Switching

Ontologies are structured collections of concepts which describe the world. Ontologies define a perspective on the domain under consideration and have been an important tool for knowledge management.

The disparity of ontologies has often been discussed as a major problem for mutual understanding and the sharing of knowledge. Most knowledge domains have been organized into ontologies several times form different perspectives. Each perspective is justified within its own context. Ontologies also differ over time. An example is the international patent classification system[1] (IPC) which needs to be adapted to new scientific and technological developments in order to integrate new innovations. Consequently, each version of the IPC represents a description of the technology at one point in time and none of the older version is wrong. Furthermore, all versions are valuable for the user of patents because older assignments of patents to classes are not reviewed and updated after a change of the classification system.

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[1] http://www.wipo.int/classifications/ipc/en/index.html

As a consequence, information system engineers are faced with a large variety of ontologies for each knowledge domain. Sharing knowledge across different perspectives represented by semantically heterogeneous ontologies remains tedious.

Our ontology switching approach does not try to unify the semantic representations by fusing the heterogeneous ontologies. Much rather it integrates all relevant ontologies into one user interface and allows the user to chose his current perspective. That means, the user can change the viewpoint form which he explores the knowledge objects.

The user selection can be changed at any point in the system. Switching causes a dynamic reorganization of the objects according to the selected perspective. The switching process invokes a process which display the new concepts, populates them with the knowledge objects and sets the current focus based on the position in the previous ontology. This can be done either based on a class or an object level. In the first case the user is presented with a view on the class from the selected ontology most similar to the one he had viewed in the previous ontology. In the second case, the same object is still shown to the user, however, it has been dynamically introduced into the selected ontology.

The remainder of the paper is organized as follows. The second section discusses the heterogeneity of ontologies. Section three presents the ontology switching approach as a theoretical concept. Section four shows the implementations of the concept in information systems. The outlook points to areas of further development.

2 The Ontology Switching Approach

The central idea of ontology switching is that the user should be enabled to change the ontology with which he wants to explore the knowledge objects in a unified collection. By allowing that, the user can select the appropriate perspective for his current context.

Enabling ontology switching within each concept is motivated by principles from human-computer interaction. For the interaction, parameters once set by the user should be kept and the user should not be forced to enter them again. Within ontology switching, the parameter setting is done by selecting concepts thus expressing interest for them. Simply changing the underlying ordering structure by selecting another ontology should not invalidate the expressed interest and force the user to search for the concept of his interest in the newly selected ontology again.

Ontology switching [Mandl & Womser-Hacker 2003] deals with heterogeneity in several levels. It integrates several overlapping collections indexed with different ontologies. Ontology switching provides a browsing system with a user interface containing all classifications. Between the ontology entries and the documents, relations need to be established where they cannot be found in the original system. For example, when a book is only available in one library, we need to index this book with terms from other library catalogues as well. This can be done manually, semi-automatic or fully automatic.

Ontology switching can integrate the perspective of different departments within a company. An engineer, an auditor and a manager all take a different approach toward documents available to them.

- Ontology switching results in the following value added services:
- One browsing user interface serves for several ontologies
- The reach of each ontology is increased
- Ontology switching is made possible and the user can change his perspective
- Ontology switching is based on the decision of the user and not on system limitations
- Thematic selections remain effective during switching and are not lost

Ontology switching is an application based on ontology learning. It exploits knowledge engineering and the results of the assignment of objects to ontology concepts. That way, ontology switching systems, create transparency in semantic heterogeneity.

Ontology switching also supports ontology learning. Continuous use of Ontology switching systems allow the identification of highly used ontologies as well as fractions of ontologies which are accessed more than others. These popularity measures can be exploited in further ontology refinement.

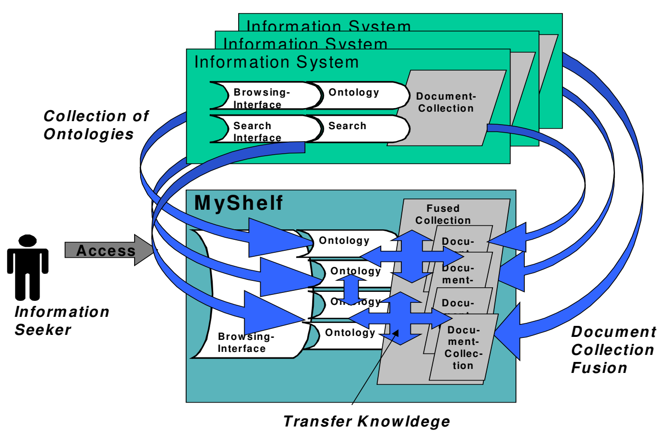

Fig. 1: MyShelf as an integrated information system

Multiple assignments are also possible within ontology switching. Often, machine learning systems assign vague membership values to objects. These vague assignments can be integrated in several ways into ontology switching systems:

- Complete ranked list within a concept
- Object is only assigned to the concept where it receives its maximum membership value
- Combinations between the two approaches above

3 Implementation of the Ontology Switching Approach

Ontology switching was first implemented within MyShelf, which allows access to information science content. Three different prototypes have been implemented, one static HTML system, one based on a database and PHP scripts and a last one applying semantic web technology. First, the knowledge engineering for the domain is described.

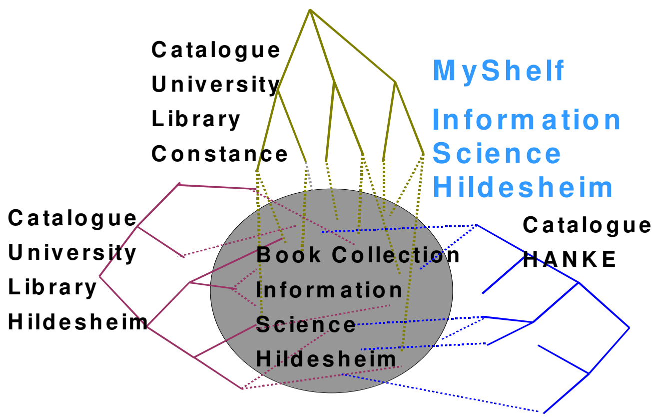

Fig. 2: Knowledge structures for MyShelf

3.1 Ontology Development and Knowledge Engineering for Ontology Switching

First, some 6000 books from the university library of Hildesheim were identified. These information science books were also searched in the library of the university of Constance. In a semi-automatic process, all books were assigned to categories in both ontologies [Hanke et al. 2002]. Furthermore, a new information science classification was designed which better models the specific teaching and research profile of the information science at the university of Hildesheim. This newly developed ontology is called HArmonized NomenKlature information sciencE (HANKE). It also mirrors recent developments in information science and information technology. As a result of this work, some 6000 documents were assigned with terms or categories from three classifications, the HANKE classification, the older classification for computer and information science called KID (cybernetics, information and documentation), developed and used by the university library of Constance, Germany and the catalogue of the university library of Hildesheim [Hanke et al. 2002].

3.2 Database prototype of MyShelf for Information Science Content

The second prototype is based on a relational database and applies PHP technology to display the objects assigned to the ontology concepts[2]. In addition to the library books described in the previous section, quality checked URLs have been included into the database. That allows the user to explore both relevant links and books within the same interface. The ontology switching applies for both links and books [Wilhelm 2004].

Most of the links have been taken from a previously constructed clearinghouse for computational linguistics. In addition, links on information retrieval have also been identified and evaluated.

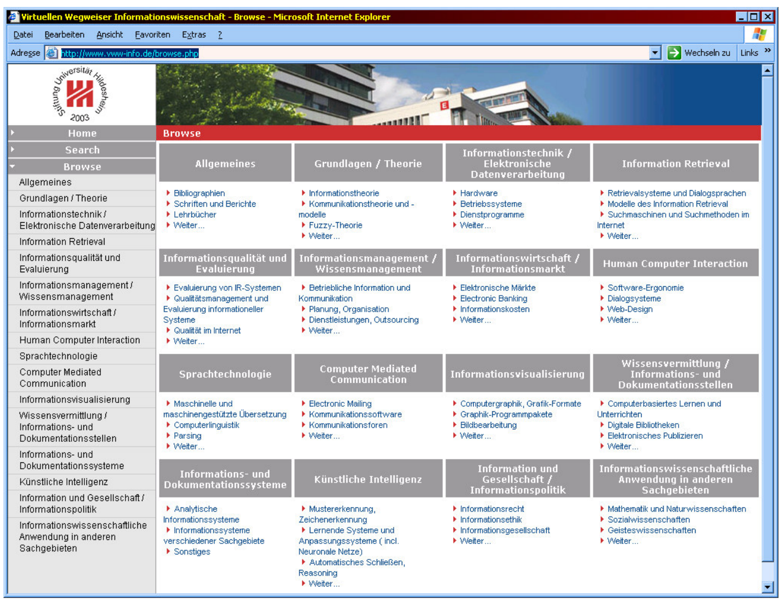

Fig. 3: User interface of the second prototype of MyShelf (cf. Wilhelm 2004)

4 Outlook

Obviously, the idea of ontology switching is well suited to be implemented within the semantic web framework. The semantic web standards have been developed for enabling the exchange of data between applications. Furthermore, the application MyShelf can be extended to include further ontologies which could be on the web. Therefore, a third prototype of MyShelf is being implemented with semantic web technology [Kölle et al. 2004].

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[2] http://www.vww-info.de/browse.php

The ontology switching approach is currently further developed by continuing to combine approaches and technologies from knowledge management and human-computer interaction. We intend to include additional data source like other ontologies for information science literature. Furthermore, more tests with user interfaces are necessary based on the results of a previous test [Heinz et al. 2003].

For future projects, not only intellectually designed ontologies will be considered. Since ontology switching allows various viewpoints, we will create several automatically constructed ontologies for the domain. Tools for ontology learning construct these structures from full text documents [Maedche et al. 2002].

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