

AN APPROACH TO A GRAPHICAL QUERY EDITOR

For Ontology-based Knowledge Management

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Abstract: The OnToBau research project aims to provide a way to classify, archive and effectively use business knowledge with the assistance of an ontology-based knowledge archive for small and medium companies of the construction industry. This archive is intended to pro-actively provide users with information which will assist them in their daily business process handling. The targeted system consists of four main parts. In this paper we mainly discuss a component for querying ontologies easily. We claim that such a component should allow graphical queries in order to be suitable for non-experienced users in our application domain and we present our approach to a *visual query system* and sketch how this can be embedded in the worker's environment. This graphical interface will allow a knowledge worker to actively search for information in an ontology and is a first step to a personal agent.

1 INTRODUCTION

The growing importance of computers in the 70s and the associated opportunity to disseminate information in digital form, is considered the turning point to today's information age. As with any other technological revolution in history, the new information technologies spread within two decades all over the planet (Castell, 2001). For the first time, it was possible to produce, to copy and to archive information in a simple way.

In the early 90s another technological milestone was passed, that moved the world to a new era of globalization (Böder, 2003). The Internet offered the opportunity to access and produce information on an increasing number of websites.

The largest flow of information on the Internet is produced by e-mails. A study of the Radicati Group in 2009 stated that in the same year about 247 billion e-mails per day would be sent, and that this number would be doubled by the year 2013. However, approximately 81% of those e-mails can be considered spam (Lyman and Varian, 2003)(Radicati and Khmartseva, 2009). This information overload will be a challenge for many companies in coming years. This is also covered by the same study: it is estimated that companies with 1,000 or more employees have to invest 1.8 million dollars per year in the processing of

e-mails and spam (Radicati and Khmartseva, 2009).

However, not only the flood of information from the growing e-mail traffic will challenge the companies in the near future. A study of the Gartner Inc. in 2002 amongst around 300 companies showed that 96% suffer an information overload. To counteract the information overload, companies will have to spend 30 billion US-Dollars within the next years (Goasduff, 2002). A similar investigation of the Baxex Inc. in 2008 stated, that the consequences of information overload produce costs of about 900 billion US-Dollars a year for the economy of the United States, caused by reduced productivity of the employees in knowledge intensive processes, which have to spent about 25% of their daily work with the search for information (Spira, 2008).

A significant problem when searching for information in digital data storages is, that the user has to know the query language of the underlying storage system (e.g. a database or an ontology). Therefore, query systems simplify the query construction by hiding the target query language. To offer the end-user an easy and effective search for information in the knowledge archive, we present our approach of a diagram-based visual query editor.

The remainder of the paper is organized as follows. First we give an overview of related work in visual query systems in Section 2. The overall sys-

tem architecture is described in Section 3, with an overview of the main components. In Section 4 we particularly discuss the visual query editor. Finally, we end up with the conclusion and outline some future work.

2 RELATED WORK

In this section we will give an overview of similar research projects considered in the area of graphical query construction, particularly in the context of ontologies.

Most approaches to support the end-user with the query formulation have focused on visual techniques to hide the target query language, like SQL for databases or SPARQL in the context of ontologies. (Catarci, 1997) presents a classification scheme of 4 different graphical query construction categories of visual query systems (VQS). The tool described in this paper belongs to the category of diagram-based systems, that tend to be the most popular. There have been a few previous approaches to support a visual query construction particularly for ontologies. Some examples include SPARQLViz (Borsje and Embregts, 2006) and NITELIGHT (Russell and Smart, 2008).

SPARQLViz (Borsje and Embregts, 2006) aims to help the user in query constructions for SPARQL. The main difference to our approach is the interaction with the user interface. SPARQLViz relies on a form-based VQS with a wizard-like interface design, guiding the user through different forms. In contrast, we present a diagram-based system. There seem to be no empirical studies on the different VQS categories, so it is difficult to compare these different approaches.

NITELIGHT (Russell and Smart, 2008) is a VQS that has much in common with the VQS presented in this paper and influenced our research to some degree. NITELIGHT supports the user with respect to the specification of all SPARQL query result forms (like SELECT, CONSTRUCT etc.). NITELIGHT also offers the possibilities of result ordering, filtering and limiting the results. It is a diagram-based VQS that offers ontology browsing and drag-and-drop functionality with a graph-based visualization. Despite these similarities the following differences do exist between NITELIGHT and our approach. First, the visual query language (VQL) presented in this paper is richer compared to the VQL supported by NITELIGHT. The VQL presented in this paper offers further possibilities on property restrictions like range and cardinality restrictions (e.g. a person, that only received invoices before 2010). Interviews with our project partners from the construction in-

dustry revealed that they often search for information where partial statements are already known (e.g. they search invoices with a particular bathtub or a tender preparation from a specific person). Therefore our VQL supports query construction including individual statements.

3 OVERVIEW OF THE ONTOBAU-ARCHITECTURE

There has been much literature about knowledge management systems (KMS) within large enterprises and little information available on KMS within SMEs (Rasheed, 2005). According to (Rasheed, 2005) SMEs have special requirements on KMS. Interviews with our project partners led to the same result. The managers in SMEs are in most cases the owners. The result is, that the decision-making process is shorter than in larger companies. They show a flat and less complex structure, with fewer layers of management (Wong and Aspinwall, 2004). Processes are often not as strongly structured as in larger enterprises and knowledge is distributed at various points in the company (file folder, product catalogs, databases) (Schwinn, 2010). A smaller number of people within a company is usually united by common beliefs and values, resulting in shorter and often less strategic ways of decision making (Rasheed, 2005). Because fewer human and financial resources are available, the introduction of a knowledge management system should not cause ongoing costs. Especially in SMEs there are no specialists for knowledge management and additional staff costs are not manageable. The goal of our project is to account for these special requirements (Schwinn et al., 2011).

During his daily work, the employee can decide whether certain resources should be transferred into the knowledge base. Those resources (e.g. an e-mail or a PDF document) are then passed to the OnToBau-System using the interface of his personal agent or plug-ins integrated in his office or e-mail software. The purpose of this section is to give an overview of the architecture of our approach. As shown in Figure 1, the OnToBau-system consists of four main parts described in the following subsections.

3.1 Document Converters

As the name implies these pre-processing components will prepare the information resources for inclusion in the knowledge base. They are converted to a general representation language, so called OnToBau Representation Language (ORL). The pre-processing

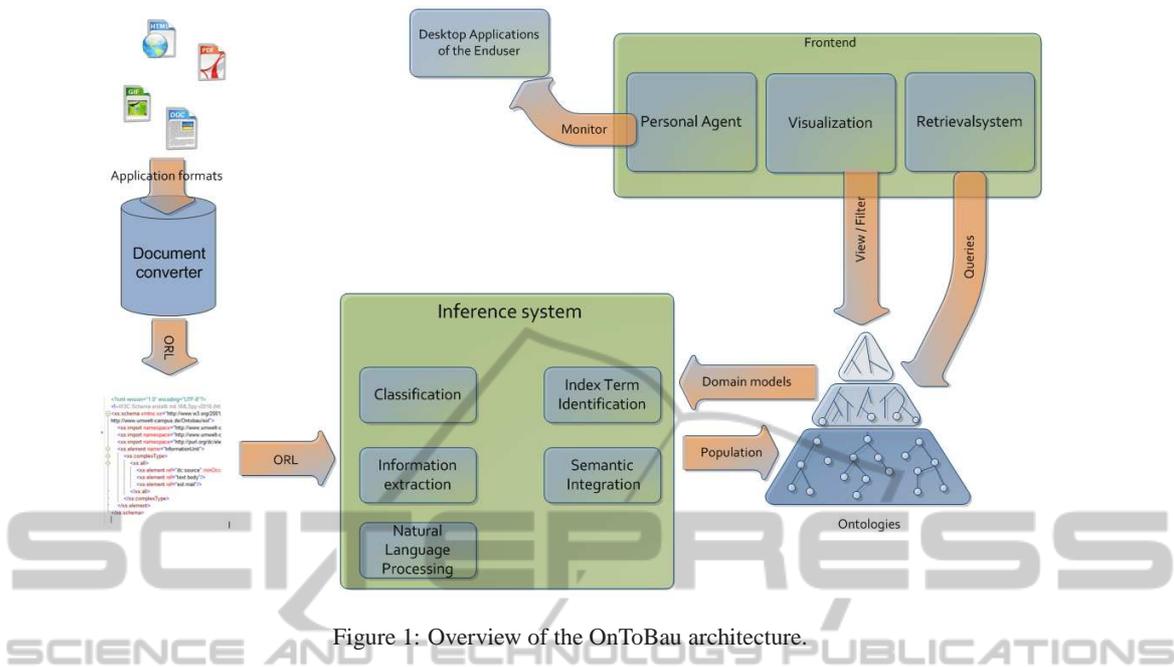


Figure 1: Overview of the OnToBau architecture.

also includes various filters (e.g. segmentation filter, part-of-speech tagger, stop word filter), which are used to simplify the subsequent processing. Interesting e-mails can be converted into the ORL directly out of the mail client.

3.2 Inference System

First, a given resource is classified into process related categories (e.g. an invoice). The domain ontologies contain the information which relevant data should be extracted from these categories. To store the information in the knowledge base we try to find relevant relationships between the new data and the existing knowledge in the knowledge base (e.g. a link between an invoice and a corresponding quotation).

3.3 Ontologies

The knowledge in the OnToBau-system is represented by using ontologies. For this, we decided to use the Web Ontology Language (OWL), which is a W3C recommendation since February 2004, so we can benefit from existing libraries and tools. The TBox of our ontology defines the terminology of the construction domain and of the business documents, thus providing the OnToBau-system with the necessary knowledge to decide which information to extract from the resources. The extracted information is stored as individuals in the ABox of the ontology.

3.4 Personal Agent and User Interfaces

The personal agent of the employee performs two main tasks. First, he should allow the employee to access the knowledge base by making specific search queries. For this purpose we implement a graphical tool for query construction described in the following chapter. Second, the agent should monitor the employees behavior and provide him pro-actively with information to fulfill his task. The second task won't be part of this paper.

Our system is based on the Eclipse RCP Framework which guarantees the ability to extend the system easily with new functions, new converters and even new graphical interface elements. Thus it will be much easier to respond to user feedback and additional requirements.

4 APPROACH TO A GRAPHICAL INTERFACE FOR COMPOSING SEMANTIC QUERIES

According to (Spira, 2008) employees in knowledge intensive processes have to spend about 25% of their daily work with the search for information. Particularly in small companies knowledge management systems can hardly be found due to the reasons mentioned in section 3. To use the corporate knowledge in the OnToBau-system actively, the employees need an

intuitive search facility. Since the knowledge is represented using OWL ontologies the queries for information are restricted to a specialized query language for ontologies.

We will describe our approach by using the example of searching a document with certain parameters: the knowledge worker is searching for quotations that have a direct relation to invoices with a recipient who is known as 'Markus Schwinn'. Additionally the query should only consider invoices which were sent from a company called 'Schottler'. The query string for receiving this information from an ontology could look like this:

Listing 1: Query example.

```

Select ?quotation Where {
  ?quotation a (quotation
and (quotationFor
some (invoice
and (hasInvoiceRecipient
value MarkusSchwinn) and
  (hasInvoiceSender
value Schottler))))).
}

```

This query might be obvious for a technically experienced person. But we can not expect the end-user to be able to state queries like this because they lack the required technical skills. Visual query systems try to establish an intuitive way to construct such a query string. Like (Russell and Smart, 2008) we decided to use SPARQL as the target query language for our approach. SPARQL is based on Turtle which isn't intended for OWL, therefore we use Terp, which combines Turtle and Manchester syntax to provide more conciseness. The user can select the entities, data and object properties of the ontology from a treeview. Contrary to NITELIGHT we decided to use individuals for query constructions too. This reflects the fact that the knowledge worker often knows some details exactly. In our example he knows the individual of the invoice recipient. Possibly this will lead to a more precise and unique query results.

The knowledge worker can drag-and-drop concepts, roles or individuals onto the query editor frame where they are represented as graphical nodes. If they are dropped onto existing nodes they are automatically connected with this node by an edge. The type of the edge depends on the different node types. When necessary the value of a node can be constraint to specify cardinalities or ranges (e.g. when searching for an invoice send by a specific company).

Figure 2 shows the same query from the example above but much more intuitive for the end-user.

The queries are modelled as a directed graph. Every node represents an ontology resource which is in fact a concept, a role or an individual. These resources were encapsulated in objects which have an additional *statement* object to indicate cardinalities and values, e.g. `min=5, exactly xyz`. If a statement object has no value (e.g. `and, not, or`) it becomes an edge connecting two nodes. Unlike (Fadhil and Haarslev, 2007), our VQS basic operators are not modelled as special nodes. The user can drop a concept onto another which already has a connection to another one. By clicking on the edge the user can define the connection.

In the background we use the Terp template interpreter to generate the SPARQL query from the graph (Sirin et al., 2010). Terp is a syntax that combines Turtle and Manchester syntaxes to provide maximum legibility and conciseness when querying OWL with SPARQL. It allows class, property and data range expressions to be used in SPARQL queries. The interpreter parses the nodes and edges in the graph and builds recursively the query string. The use of recursion offers the possibility for deeply nested queries. Every class element in the graph allows the interpreter to set a pair of enclosing brackets in the query. A graph with two class nodes (e.g. `person` and `dog`) would be translated like this:

Listing 2: Example for the conciseness of Terp syntax.

```

Select ?Person where {?Person a
  (ns0:Person and
  (ns0:has_pet some ns0:dog)).
}

```

The use of Manchester syntax makes the query easy to read. The edges of the graph reflect the cross-linkage of the objects with the keywords *and, or, not, min, max, exactly, value, some, only* as shown in the listing above.

Graphs with nothing but the root element and without an edge as well as the following keywords: *optional, filter, order by* and *owl:equivalentClass, rdfs:subClassOf* will not be implemented. For these cases it will be necessary to think of additional mechanisms in the graphical user interface.

After constructing the graphical query, the results are visualized to the knowledge worker. Choosing a possible result will present the selected individual with all its connections in a well-arranged graph. The implementation of this network is based on the Protege-Plugin Ontograf, which is slightly enhanced to improve the user experience (see figure 3). In our example these are the quotations matching the query.

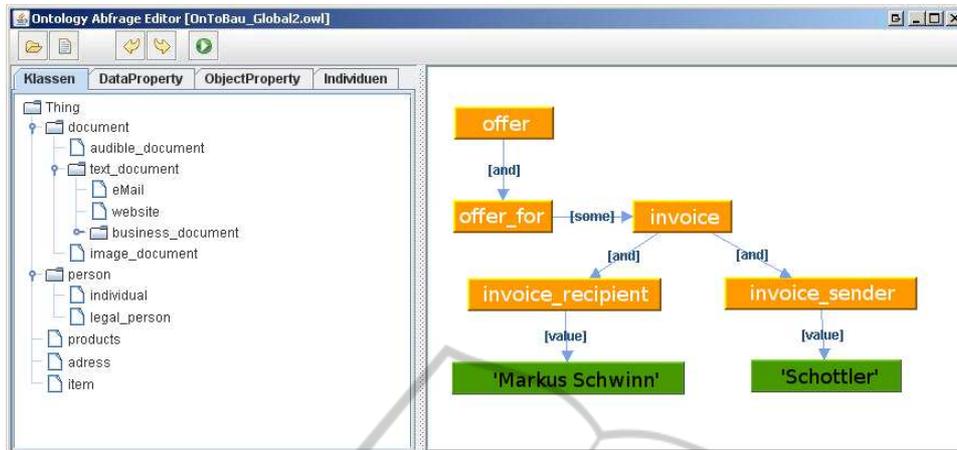


Figure 2: Complete visual query graph.

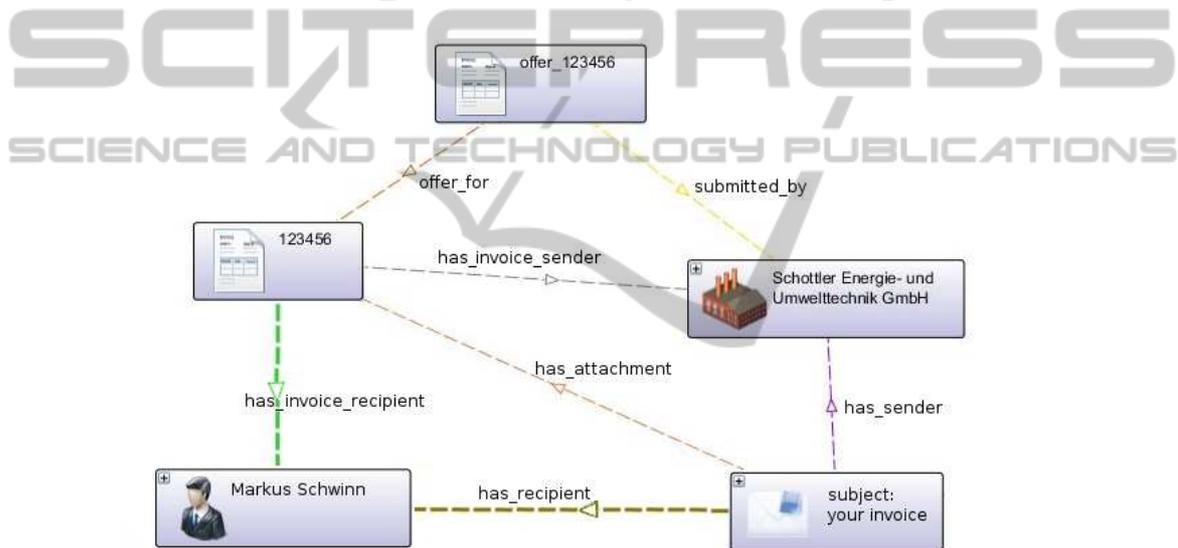


Figure 3: View of the query result.

The result graph shows additional connections, like the corresponding invoice and the company.

It is planned, but not yet implemented, to use this icon-based approach also for the query editor. In changing the diagram-based approach to a real graphical approach we expect a better acceptance on the user-side because of the improved usability.

A feature called live search is currently under development. With every change on the graphical query frame, like adding or removing nodes, changing the type of the edges or changing values, the knowledge worker will get an updated result list matching the current query term. Thus he gets an instant feedback if the query makes sense or not. This feature will create a more fluent the workflow.

5 CONCLUSIONS AND FUTURE WORK

Because there are no specific projects supporting the knowledge management process of companies in the targeted domain, the presented architecture is our approach to provide small and medium companies with an ontology-based knowledge management and information retrieval system.

An integral part of the OnToBau system, which is not yet implemented, will be the personal user agent. The agent will monitor the users activities and provide him with the relevant information for the process in real-time. To achieve this, it needs underlying behavior patterns and must try to anticipate the users

intention.

The editor for the visual query construction is a first step to this personal agent. It can provide the user with necessary knowledge, but he still has to search pro-actively. The current approach is diagram-based, but we are planning to develop an icon-based system similar to the result view presented in figure 3. This will improve the user experience because there will be no "visual gap" between query construction and result graph. We have not performed any user evaluations with our project partners, but aim to undertake such studies in the near future.

Another extension is the live search functionality. When finished it will provide the knowledge worker with a direct response on what he does in the query editor. Currently the query editor and the presentation of the result is divided in two program parts. For a fluently workflow it will be necessary to combine these into one.

Our research project focuses on the needs of construction industry but of course this approach could be adapted in other domains dealing with ontologies.

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