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Supporting the Study Process using Semantic Web Technologies

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Introduction

During the last five years (from 2006 to 2010) all study programs at the Faculty of Electrical Engineering and Computer Science, University of Maribor, have been renovated in accordance with the directions of Bologna Process. In this way, 10 first bologna degree (bachelor's) study programs have been defined (including Electrical engineering, Telecommunications, Computer Science, Informatics, Mechatronics, etc), 6 second degree (master's) programs and 3 third degree (PhD) programs. This number of study programs have resulted in a large amount of different subjects/courses (over 300, not including the PhD subjects) taught by approximately 70 teachers and 150 teaching assistants and technical staff. The number of students at our faculty exceeds 2000.

The complexity of our study programs is further enhanced by the increased dynamics of teaching settings. Some new courses, especially the practically oriented ones, are organized in such a manner that they are taught by more than one teacher, assisted by several teaching assistants and technical staff. Within such courses students are assigned with practical projects they have to perform. For this purpose, based on the specific topic of a project, students need to select their project mentors. Because students don't know all of teaching staff competences, it is not easy for them to select the most appropriate mentors.

One of the positive consequences of the renovation of our study programs according to Bologna process is the systematical description of all the subjects. These descriptions include lecturers, course content, objectives, intended learning outcomes (knowledge/understanding, transferable/key skills), etc. From these descriptions the competences of lecturers could be deducted.

The aim of this paper is to present an approach to organizing the available information about teaching staff's competences within a computerized framework for the purpose of improving the mentor selection process (and consequentially the efficiency of the study process itself). A system has been developed that helps students to find appropriate mentors (teachers, teaching assistants) according to their competences and skills using the semantic web technologies. With the use of the system it is possible to search for mentors that master specific topics, posses wanted skills and competences.

In the following section the organization of some practical courses used at our faculty is described first, then the semantic web as an enabling technology to achieve the intended goal is introduced together with the recent research directions on semantic web in education, after which the developed system is described and finally some practical examples of using the developed system along with the implications of its use are presented.

The organization of practical courses and the selection of mentors

Importance of practical work in engineering education is growing significantly [1]. Labs are most effective and important part of nowadays engineering education [2]. In this manner, the amount of practical project work and lab assignments should be increased [3]. Another reason is fresh students: in modern virtual world they have less and less capabilities to perform practical experiments and therefore they have less experience. Lack of experience makes theoretical considerations too abstract and is considered by students as something that has to be learned but has no evident practical value [1]. According to the Bologna process greater weight should be also given to practical training and to intensive research projects.

In this way, besides increasing the amount of lab assignments, at our faculty we have included a number of practically oriented courses within our study programs. The increased amount of practical work allows students to gain some experiences as near to real world as possible and improves their motivation as they feel the satisfaction because of their practical achievements [4]. Following this schema, students need to apply for and prepare proposals for practical projects. In this manner, they should select working mentors – teachers and teaching assistants that will help and instruct them during the preparation and implementation of projects.

Because of the complex structure and inherent dynamics of study programs at our faculty and the large amount of teaching staff it can be quite difficult for our students to select the appropriate mentors, regarding their competences and skills, their experiences, etc. That's why we decided to develop a system for supporting the process of selecting mentors based on the known competences and skills of teaching staff. The fundamental requirements for such a system include the formal representation of teachers' professional profiles (their competences and skills) and the possibility to manage these profiles, which includes the basic management of such information and also (at least up to some point) automatic inferring on the knowledge it provides. For example: if a teacher masters Java programming language and Java is an object oriented programming language, then the system should be able to automatically conclude that this teacher masters object oriented programming. If a student should look for someone with the knowledge of object oriented programming, staff with the experiences using Java, C#, Python etc. should be taken into consideration. While such conclusions are quite obvious from our point of view, they represent quite a task for a computer system to come to such conclusions automatically.

While the majority of the courses are available within the faculty's virtual learning environment [5], it is straightforward to extend this environment with the proposed support system, giving it new forms and opportunities and improving the quality of learning [6]. Based on our experiences from personal competences management [7] and integration of knowledge resources [8] we decided to use semantic web technologies as an enabling technology. Recent research on the use of semantic web technologies in education has shown some very promising results [9].

Semantic web as the enabling technology

According to Passin [10], the vision of semantic web is that computers would be able to find, read and understand the meaning of data. Tim Berners-Lee sees semantic web as "web of data" compared to web of documents as we know world wide web today [11]. In this manner, the semantic web technologies are able to represent knowledge in the form of semantically annotated, interconnected data.

Semantic web technologies (SWT) are based on XML language that enables them to be platform and program language independent. They are built in layers, where each upper layer provides additional functional aspects and is based on the lower one, with which it is fully compatible (http://www.w3.org/2001/sw/). The layers, from bottom up, include URI, XML and namespaces, RDF as the core technology for the semantic annotation of data [12], RDFS and OWL being languages for describing ontologies [13], Sparql a language for querying semantic data and RIF as a rule interchange format for describing logical rules of the data being semantically described.

The central part of a semantic web system is an ontology that describes some knowledge domain using notions of concepts, instances, attributes, relations and axioms – in the form of semantic data [14]. It is a useful way to organize and share information while offering means for enhanced semantic search.

A typical SWT system is based upon RDF, OWL and a rule language compatible to RIF – SWRL is widely used [15]. In this manner, RDF is mainly considered as a data backend and a data interchange technology. Concepts that are defined in ontology represent the useful information or knowledge. Rules enable encapsulation of logic – based on defined rules, new knowledge is being inferred according to concepts defined in ontology and RDF data. A query language (like Sparql) is used to query the semantic data. These building blocks represent the core SWT and comprise a typical SWT architecture which provides fairly expressive formalisms for knowledge representation and inferring on this knowledge.

Semantic web technologies in education

Educational systems are gradually incorporating SWT aiming to provide a more adaptable, personalized and intelligent learning environment, where the main research focus is to find out how the use of ontologies can enhance the potential of computer-based learning support systems [9]. The implications of using SWT for education are profound, with three main areas of impact: knowledge construction, personal learning network maintenance, and personal educational administration [16].

Research on SWT and education has already shown some of the features expected to be embedded in the next generation of learning support systems. Such features include: more adaptive and personalized learning environment; a better use of pedagogies to enhance instruction/learning; effective information sharing, storage and retrieval; new forms of collaboration with peers; and many other characteristics that enable the realization of "anytime, anywhere, anybody learning" objective [9].

One such possible feature of SWT in education is to use SWT for automatic analysis of learning content. In [17] the authors demonstrated how to use SWT to improve the state-of-the-art in online learning environments and bridge the gap between students on the one hand, and authors or teachers on the other. They presented an ontological framework that helps to formalize learning object context and showed how one can use semantic annotation to interrelate diverse learning artifacts.

Mentor selection support system

The mentor selection support system has been implemented in a form of a SWT based web application (Fig. 1). The conceptual architecture of the system is represented on Fig. 2.

For this purpose the ontology for the representation of teachers' competences has been defined first using OWL. The ontology serves as the main information model – it defines how the information about the mentors' competences and their relations to subjects' content is represented (Fig. 3). Then the information from formal subject descriptions (prepared during the renovation of study programs for the accreditation purposes) has been transformed into RDF-based semantic data in accordance with the defined ontology (Fig. 4) – it is easy to see the complexity that such amount of information represents.

Fig. 1. Simple web interface of the developed mentor selection support system

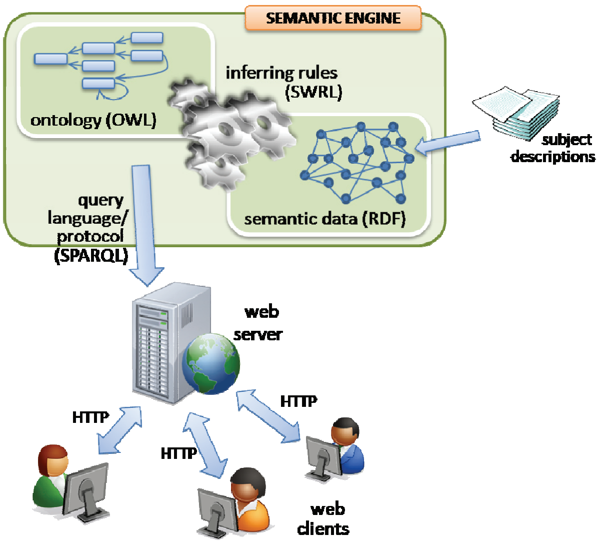

Fig. 2. The conceptual architecture of the system

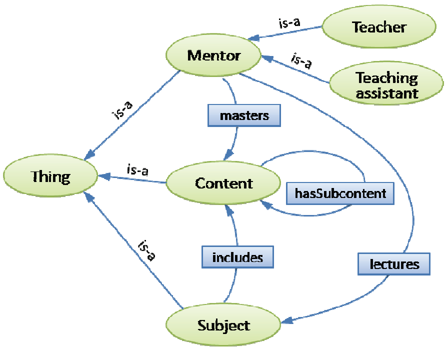

Fig. 3. The ontology representing inter-connections between mentors, subjects and the content/knowledge

When data is appropriately semantically annotated within a semantic network (represented in a form of RDF graph in accordance with the defined ontology) one can take advantage of such a knowledge model to infer on information it represents.

For this purpose two components of semantic web technologies are available – Sparql and SWRL. Sparql is a protocol and query language for semantic data, which means that it can be used to query the semantic network for information. In this manner, we can for example display all the competences of a specific teacher, search for all the teachers mastering a specific topic, etc.

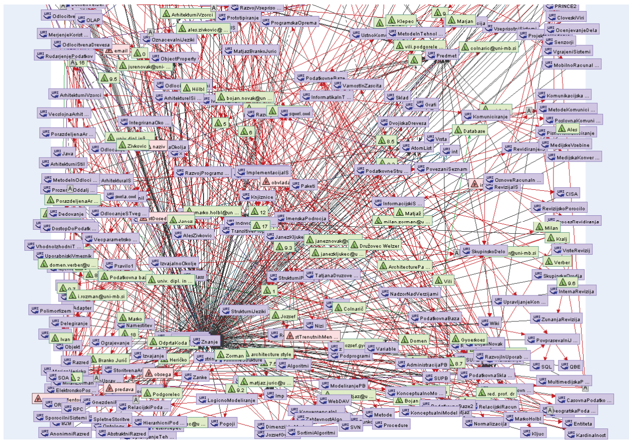

Fig. 4. The resulting semantic data network comprising all the competences of teachers (for one study program)

The following query returns all the content for all the courses:

```
PREFIX helpSt: <http://www.helpSt.com/12721.owl#>
SELECT ?subject, ?content
WHERE {
   ?subject  helpSt:includes  ?content
}
```

Rules within SWT represent the advanced logic used for inferring the semantic data. There are several rule languages available for defining rules within SWT, one of the mostly used one being SWRL (Semantic Web Rule Language). It combines OWL and RuleML (Rule Markup Language) and is based on description logic. The explanation of the following rule is when/if a lecturer x lectures a course y and this course y includes content z then it can be concluded that lecturer x masters the content z.

```
helpSt:lectures(?x, ?y) ∧ helpSt:includes(?y, ?z)
→  helpSt:masters(?x, ?z)
```

Using the presented support system students are able to find teachers and teaching assistants according to their competences and knowledge content they are lecturing, even though if they don't know them or haven't participated in one of theirs courses. Beside competences which naturally are the most important aspect, some additional data (availability of a teacher, students' mark, etc.) is also taken into consideration when searching for a mentor. In this manner every student can select those teachers and assistants who should best help him/her in preparing and implementing their practical projects. In this manner not only the mentor selection process is facilitated, but also the motivation of students is increased (while they are working on practical projects of their interest with the teachers experienced in the field) and consequentially the knowledge level of students. While students are asked to provide a feedback about the chosen mentors, this information can be used by teachers and department chairs as an evaluation of their work and a measure to improve the quality of the study process itself.

Conclusions

While renovating our study programs we were not aware of all the practical consequences it will have on the study process, on students and on teachers. Wanting to provide students with the best learning possibilities (increased amount of practical work, optional courses, individual selection of projects, etc) the complexity of our study programs increased more than expected and hindered the positive aspects of planned educational elements.

The research results of using semantic web technologies in education provided us with a good base for developing a mentor selection support system. After one year of experimental use of the system we can confirm our expectations that students are very inclined to use this kind of support. Also the teachers find it useful. Apparently, using the presented system students are preparing their practical projects more in sync with the research topics of the teachers, while maintaining the level of motivation as they can propose their own project topics.

Both students and teaching staff are starting to get aware of the benefits such a system carries. However, there are still some technical and organizational problems when using the system. Because the system is not integrated with the subject descriptions database, the competence profiles are not automatically updated. Not all the competences of a teacher are included in subject descriptions, and not all the teachers are using our system. We could conclude that the presented system is technically capable of automating the mentor selection process (up to a reasonable point). Whether its potentials will be actually realized lies primarily on the teachers themselves.

Finally, it must be emphasized that the presented mentor selection support system itself started as a practical project proposal from one of our master's degree students (the second author of this paper). When the final prototype of the system has been developed, both other students and teachers were very interested in seeing what this kind of cooperation between a student and a professor could bring.

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The complexity of study process at our faculty (several study programs, the dynamics of 220 teaching staff, more than 300 courses and over 2000 students) represents a great obstacle for our students who have to select mentors for their practical projects. Based on some very promising results of using semantic web technologies in education we developed a mentor selection support system, which is presented in this paper. Having the competences and skills regarding specific topics represented in a form of ontology-based semantic network enabled us to retrieve this information automatically. The results show some very positive aspects of using the system, both for students and teaching staff. Ill. 4, bibl. 17 (in English; abstracts in English and Lithuanian).

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Nagrinėjamame fakulteto studijų procese didele kliūtimi laikomas praktiniams projektams skirto mentoriaus pasirinkimas. Taikant semantinio tinklo technologijas, buvo sudaryta mentorių atrankos palaikymo sistema, duodanti labai gerų rezultatų. Tokiu atveju tinkamai panaudojamos turimos žinios ir kompetencijos. Gauti rezultatai rodo, kad tokią sistemą teigiamai vertina tiek studentai, tiek patys dėstytojai. Il. 4, bibl. 17 (anglų kalba; santraukos anglų ir lietuvių k.).