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E-LEARNING TOOLS: CONCEPTUALISATION OF DOMAIN KNOWLEDGE FOR FUTURE USE IN E-LEARNING CONTEXT

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ABSTRACT: Semantic Web is a Web of new generation. The main difference from the Web of the first generation is that information presented is understandable not only for humans, but also for software agents or other software modules. Ontologies are most often defined as basic component in Semantic Web infrastructure. Domain ontologies provide shared and common understanding of a specific domain. They, as engineering artefacts, are used in different fields, including e-learning. In this paper, we present the development of domain ontology for future use in e-learning context. Domain of "E-learning tools" was chosen for implementation. The distance learning course "E-learning technologies" (3 credits) is elective and oriented not only for students with strong background of information technologies. Among others, the expected ability of the study module is formulated as follows: students will be able to analyse, compare and in the real context to choose the most suitable tools for development of study materials, delivering distance learning course or making other decision in e-learning context. Our domain consists of three large parts: tools (software products), technologies in a wider sense of this word and didactics. The obstacle of our solution is that the domain is evolving quickly. But since we agree that "there is no single correct ontology for any domain" (Noy, 2001), we can freely experiment and foresee further use of developed ontology in e-learning.

Key words: Domain ontology, ontology development, e-learning, e-learning tools

INTRODUCTION

Ontology is an emerging instrument for knowledge representation, share, reuse and interoperability. Some of the definitions of ontology, used in computer science field, are presented in (Guizzardi, 2005), and they are summarised below:

- "Ontology is a representation of a conceptual system that is characterized by specific logical properties". This definition accentuates the collection of statements or other semantic definitions for a domain.
- "Ontology is a synonym of conceptualization". This definition emphasizes, that we deal with an abstract, simplified view of the part of the world.
- "Ontology is a special kind of knowledge bases". This definition emphasizes, that ontology is engineering artefact.

Ontologies are most often defined as basic component in Semantic Web infrastructure. Semantic web technologies can enhance possibilities and functionality of traditional Web. For example, Davis (2007) characterises the business value of semantic technologies in five critical areas:

- Development. In this aspect, some automation in different steps of development of information system becomes possible. Semantic Web technologies allow to manage better software system's complexity, to fit better in project's time period, to reduce risk.
- Infrastructure. Modern information systems are net-centric, distributed, rapidly evolving. Semantic technologies provide possibility to orchestrate core computing processes.
- Information. We deal with information overload and semantic inconsistency. Semantic technologies strive for semantic interoperability of information and applications in real context.
- Knowledge. Semantic Web technologies provide possibilities to knowledge work automation and supporting knowledge workers.
- Behaviour. The final aim is a situation, where "systems know what they are doing". It is achievable over implementing of adaptivity, machine learning, and automatic reasoning mechanisms.

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Ontologies, as engineering artefacts, are used in different fields, including e-learning. The aim of this presentation is to analyse the types of domain ontologies and to present our practical work in the field of development of ontology. Domain of "E-learning tools" was chosen for implementation.

DIFFERENT TYPES OF ONTOLOGIES

Literature review shows that there are different classifications of ontologies. Some of them concern different aspects, e.g. generality level, richness; some of them are alternatives of some kind. Different classifications are comprehensively analysed in (Ruiz, 2006). Here we highlight more important in our viewpoint classifications, which enforce us to choose one alternative, and briefly summarise the other classifications.

There can be two types of ontologies, depending upon a language used for formalisation and the purpose of ontology: lightweight and heavyweight. Lightweight ontologies include concepts with properties and taxonomies, but do not include axioms. Heavyweight ontologies are richer in expressiveness, but they are harder to manage. Since the lightweight ontologies are less restrictive, they are usually wider acceptable, which is very important for knowledge sharing and reuse. We are planning to find balance between expressiveness and decidability. The less expressiveness the language provides, the better reasoning mechanisms are implemented. This is very important in the context of immediate feedback generation and increasing efficiency of system in common and simple tasks.

Other classification of ontology as schema-ontology and topic-ontology is introduced in (Kiryakov, 2006). Concepts with intuitive relations, for example Africa and Nile, can be related in topic-based ontologies. However, if we want to implement effective reasoning algoritms, we should use schema-based ontologies. Also the author accentuates the possibility to formalise the domain while using set-theoretical model and set theoretical operations.

Several other classifications of ontologies are summarised in Table 1.

Table 1. Classifications of Ontologies

Aspect	Proposed by	Types mentioned
Generality level	Guarino (1998)	High–level ontologies Domain ontologies Task ontologies Application ontologies
	Fensel (2003)	Generic or common-sense ontologies Representational ontologies Domain ontologies Method and task ontologies
Type of conceptualisation structure	Van Heist (1997)	Terminological ontologies specify the terms that are used to represent knowledge in the domain. Information ontologies specify the record structure of databases. Knowledge modeling ontologies specify conceptualizations of the knowledge.
Richness of internal structure	Lassila (2001)	Controlled vocabulary - a finite list of terms. Glossary - a list of terms and meanings. Thesauri - provides some additional semantics. Term hierarchies (or informal hierarchies) - provides generalisation and specialization. Strict subclass hierarchies (or formal hierarchies). Frames – includes property information. Ontology with value restrictions. Ontology with logical constraints.
Formality	Uschold (1996)	Formal, e.g., expressed in first-order logic. Informal, e.g., expressed in natural language. Semi-formal, e.g., expressed in UML.

We choose lightweight, schema-based, semi-formal domain ontology for capturing subject domain knowledge, because:

1) It better corresponds with our understanding of the concept of ontology;
2) It deals with formal or semiformal representation;
3) It represents a top-down systematic approach;
4) It better fits in our instructor-led e-Learning context.

MANUAL AND AUTOMATIC ONTOLOGY DEVELOPMENT

Two main types of ontology development are distinguished:
1) Manual ontology development. The main design and development processes are done by humans. We argue for the manual ontology development because of the following reason: despite of the fact, that there are still much heuristics in the development of domain ontology manually, it remains still the best approach to the development of ontology of high quality. The main problem while using this approach is that such task is very time consuming.
2) Automatic or semi-automatic ontology development. In the future we have plans to experiment with semi-automatic methods for ontology (starting from its structural base - taxonomy) development, in order to find easier ways to build the main corpus of knowledge from particular domain. But at this moment there are no suitable tools for automatic ontology development, especially if we suppose that our concepts and relations must be expressed in Lithuania.
The main characteristics of manual ontology development are presented in Table 2.

Table 2. Characteristics of Manual Ontology Development

Characteristics	Description
Typical processes	The consensus of different methodologies is the following list (Uschold, 1996; Fernández-López et al., 2004; Grobelnik, 2006): Pre-development (domain and data understanding, purpose and scope definition). Development (practical dealing with concepts, relationships, instances). Post-development (evaluation, evolution).
Main advantages	Better quality can be reached. Reliability. Top-down approach can be used, what implies better systematisation.
Main shortcomings	A great amount of time from both domain experts and knowledge engineers is required. Cost (human resources).
Involvement of the humans	In all processes.
Support provided by tools	Ontology editors; Ontology visualisers (useful in evaluation of domain ontology of domain experts); Reasoners (useful in finding contradictions).

CASE STUDY: CONCEPTUALISATION OF E-LEARNING TOOLS DOMAIN

Domain ***E-learning tools*** was chosen for implementation. Ontology is intended to be used in the distance study course "E-learning technologies". The course is implemented using MOODLE: a free, open source course management system. Therefore, we already have learning material, which can be linked to the concepts from domain ontology.
Among others, the expected ability of this course is formulated as follows: students will be able to analyse, compare and in the real context to choose the most suitable tools for development of study materials, delivering distance learning course or making other decision in e-learning context.
The main general concepts in our domain are: *SoftwareProduct*, *Manufacturer*, *Purpose*, *CurriculumLevel*, *Learning Activity*, *Task*, *User Role*. We employ a whole-part relationship in order to represent aggregation (see Figure 1).

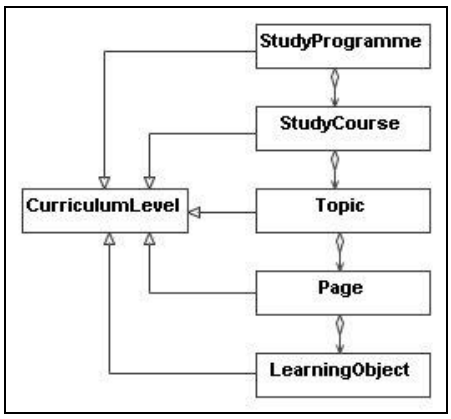

Figure 1. Example of Whole-Part Relationship

Also, other different types of functional relationships are employed, for example, *provides*, *isProvided*, *isSuitableFor*, *canBeAchievedWith*. They link general concepts. The largest part of ontology is represented as taxonomical hierarchies. The bigest taxonomical hierarchy starts from the concept *SoftwareProduct.* The part of this hierarchy is presented in Figure 2.

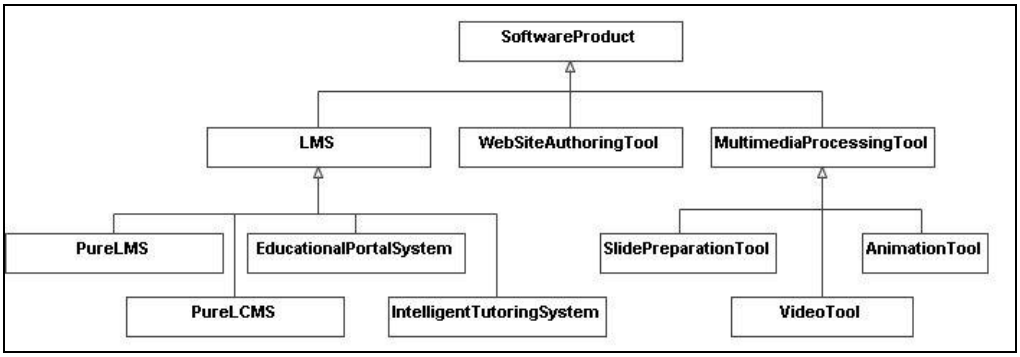

Figure 2. The Part of Taxonomical Structure

Concrete tools, discussed in the course and treated as instances from ontology-based view, are selected from the variety of tools from basically two types: 1) Best, industry leading tools in the field; 2) Free tools. The lists of important properties are defined considering, what type of information is useful when we want to choose a tool for some job in eLearning field. One of the special properties, usually not mentioned in web sites with tools' ratings, is possibility to translate captions of user interface elements into Lithuanian.

CONCLUSION

In different cases different ontology development methods are applicable: manual ontology development, reusing existing ontologies, semi-automatic development of domain ontology. Despite of the methodologies for the manual development of ontology are underdeveloped, and there are still much heuristics in the development process, it is the way in which at the moment higher quality ontologies can be made.

Lightweight, schema-based, semi-formal domain ontology for capturing subject domain knowledge should be used, because it 1) better fits in instructor-led e-Learning context; 2) is more suitable for further reasoning over it.

Instances (the A-Box of ontology) are evolving very rapidly. It requires some semi-automatic processes for further renewing domain ontology.

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