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SYSTEM FOR LEARNING OBJECTS RETRIEVAL IN ONTOLOGY-BASED DATABASE COURSE

JOVANA JOVIĆ
Belgrade Metropolitan University, Faculty of Information Technologies, jovana.jovic@metropolitan.ac.rs

SVETLANA CVETANOVIĆ
Belgrade Metropolitan University, Faculty of Information Technologies, svetlana.cvetanovic@metropolitan.ac.rs

MIROSLAVA RASPOPOVIĆ
Belgrade Metropolitan University, Faculty of Information Technologies, miroslava.raspopovic@metropolitan.ac.rs

Abstract: *The aim of this work is to present how implementation of an ontology model in the online course based on learning objects (LOs) can be used to provide personalized learning material for the learner. In this model, learning materials are organized using its developed ontology, while its structure is visually presented as a graph so that it is easier for the learner to navigate through course topics. Each topic consists of a sequence of LOs and is represented as a node in the graph. Different types of relations were used: (i) relation between topic and corresponding subtopics describing that a subtopic is a part of another higher-level topic (ii) relation between the topic and its corresponding LOs noting that content of an LO is a part of a certain topic and (iii) relation between LOs which provide an information that LO has a pre-requisite LOs. Lexicon of LOs' keywords is also presented and mappings between the keywords and topics in the ontology are performed. Each keyword is linked to a corresponding topic, and vice versa – each topic in the ontology consists of at least one keyword. Benefits of using described relations are to allow easier navigation through learning material for the purpose of providing personalized content for adaptive learning. The scenario of the ontology usage during the learning process is also described through the ontology for Database course is presented.*

1. INTRODUCTION

The rapid growth of e-learning has changed traditional learning behavior and presented a new situation to both tutors and learners. While traditional e-learning systems are used to publish learning materials in the format of written lectures, the tendencies of the new e-learning systems are steering towards the personalization of learning materials for each student [1]. A personalized e-learning system refers to an education system that focuses on learning that is tailored to the needs, attitudes, and interests of every learner [2]. The process of personalization of e-learning does not involve only the ability to customize the learning environment, but also to personalize many other aspects of the entire learning experience such as how the content should be delivered, how students will be evaluated, what feedback mechanisms will be offered etc. Personalized learning is a key strategy for improving student engagement and academic achievement [3].

An approach that represents a good candidate to achieve personalization in learning is to divide learning materials into smaller modular units that are referred to as learning objects (LOs). LOs can be defined as "any digital resource that can be reused to support learning" [4]. The idea of using eLearning system based on LOs is to create learning material that is: (i) interoperable (can "plug-and-play" with any system or delivery tool, (ii) reusable (can be used or adapted for use in multiple learning contents), (iii) accessible and (iv) manageable (can be tracked and updated over time). Personalized systems do not provide only additional possibilities for direct access to the learning content in LOs, but also is suitable for an adaptive instructional design that relies on frequent evaluation and alternation [5].

Besides using modular reusable units of learning material, another requirement for achieving personalization is the usage of ontology. Ontology is a science that studies explicit formal specifications of the terms (concepts, relations, functions, and instances) in some domain of interest [6]. Representing knowledge in the form of ontologies enhances the management and retrieval of the learning material within personalized eLearning system and has very important role in the automatic processing of learning material [7].

In the relevant literature, there are a lot of proposed approaches which consider different ways how ontology can help the process of personalized learning. Monachesi et al. proposed LT4eL system, which uses ontologies in order to improve the reusability of available LOs within a Learning Management System, while allowing cross-lingual retrieval [7]. Their work approaches solving this

problem of multilingual environments by using a multi-language lexicon.
Chung and Kim describe ontology-based e-learning system which allows learners to build adaptive learning paths using the curriculum, syllabuses, ontology of course and topics [8]. By comparing student-learning outcomes before and after applying ontology approach to the class, authors conclude that the ontology-based teaching and learning enhances the learning outcomes.
Taking into discussion the particular case of the Computer Science field and its ACM classification system, Brut presents an ontology-based system and a search mechanism that establishes the relevance of each material for a certain topic, but results of system evaluation are not shown [9]. Capuano et. al considered ontologies as a basis for personalization of the IWT eLearning system which uses ontologies, annotated LOs and learner profiling to automatically assemble and deliver personalized content. [10].They concluded that the introduction of personalization led to a relevant increase in the percentage of students who successfully completed an exam.
The objective of this paper is to present how the ontology can enhance the flexibility of the learning process in the online course and provide personalized learning material that is delivered to a learner. In order to verify the defined objective of this paper, the model of course material retrieval using ontology based on the ontology for a Database course specified by IEEE Computer Society's Information Technology 2008 Curriculum Guidelines for Undergraduate Degree Programs is presented [10].

The paper is organized as follows: Section 2 describes the ontology model for the Database course that consists of hierarchical components such as curriculum, course, course topics and its subtopics, LOs, and the corresponding relation between them. Section 3 describes the model of LOs retrieval demonstrated on the example of the ontology of the Database course. Described model enables students to find the most suitable learning path by navigating through ontology regardless of whether a learner is a beginner or not. Section 4 concludes the paper.

2. ONTOLOGY MODEL DEVELOPMENT FOR DATABASE COURSE

This work is using results of the previous work done by Cvetanovic and Raspopovic who developed the domain ontology for the key concepts for the Database course based on the body of knowledge defined in IEEE Computer Society's Information Technology 2008 Curriculum Guidelines for Undergraduate Degree Programs [11]. For the Database course, Information Management knowledge area defined in IEEE curriculum was used. In this particular knowledge area, ontology is defined at several levels, starting from high-level topics and branching out in hierarchical fashion all the way to the smaller subtopics. Several ontology components of hierarchical ontology architecture are given (Figure 1): (i) curriculum, (ii) courses, (iii) topics, (iv) subtopics and (v) LOs. LOs represent the smallest components in this hierarchy and they contain learning content. The features of each component in the ontology are described with appropriate metadata.
An ontology that is developed for any domain, or in this case knowledge area, should conceptualize and contain elements that include information about the academic program where this area is thought, courses that utilize this knowledge area, key topics, learning outcomes and pedagogy methods used in the delivery of the learning material (teaching methods, delivery modes, etc.).
Similarly to the knowledge area that contains its ontology, the course also has its ontology containing of topics, subtopics and belonging LOs.
Topic ontology described the topics and the subtopics that are thought during the course. In order to achieve reusability of learning materials, each subtopic may be further divided into smallest units - LOs. LOs are described by metadata consisting of a title, author, objective, education level, a level of difficulties, interactivity level and type, copyright, keywords etc.

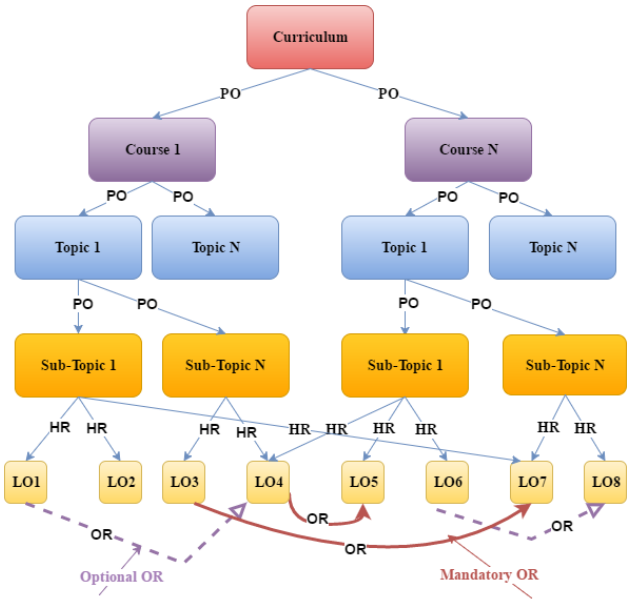

Figure 1 - The model of database ontology

Relations between ontology components are also specified. Three types of relations were used (i) "*part of*" (PO) relation used between different topics that describe that a subtopic is a part of another higher-level topic (ii) *"has resource"* (HR) relation used between a topic/subtopic and LOs means that LOs content explains the corresponding topic or subtopic (iii) "*order relations*" (OR) between LOs. OR relation is used in two cases: (i) it can be used to represent a mandatory relation providing an information that LO has a pre-requisite LO, which should be learned before accessing that specific LO (ii) or it can be used as an optional relation that represents only a recommendation which LOs may be learned before and that are typically learned by students who want to gain deeper knowledge. These relations (PO, HR, OR) are shown in Figure 1 (mandatory and optional relations are depicted by a single red line and a dotted purple line respectively).

It is important to say, that optional and mandatory relations can be established between LOs that do not belong to the same topic, which enable that LO content from a course can be reused in other courses as recommended or mandatory learning material.

In order to present the importance of ontologies in LOs retrieval, a lexicon of keywords is created and corresponding mapping between lexicon and ontology is established. This mapping has the aim to link each keyword from lexicon to a corresponding topic in the ontology and inversely to connect each topic in the ontology to at least one key word. Overview of the ontology and associated keywords in the lexicon is presented in Figure 2.
In this phase of the project, lexicon contains only keywords that are manually related to the specific LOs as metadata description. In order to provide a lexicon with keywords connected by meaning, synonym relation between correspondent terms needs to be established.

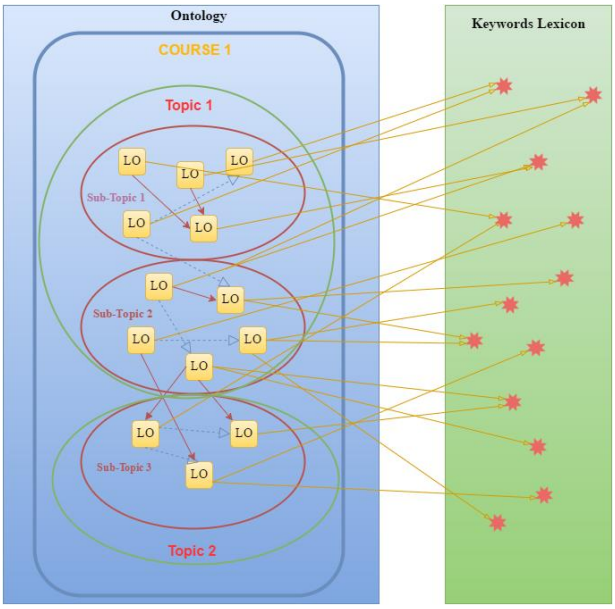

Figure 2: The relation between ontology and lexicons of keywords

Figure 2 depicts that keywords do not only describe LOs to which they are directly connected but are also based on *PO relation* in the ontology, correspondent subtopics, topic, and course. For example, Topic 1 in Figure 2 includes Subtopic 1 and Subtopic 2, which are described by keywords allocated to LOs belonging to these subtopics. Set of keywords that describe Topic 1 is obtained as the union of keywords that describe Subtopic 1 and Subtopic 2.

The defined model of the Database ontology and the relations between ontology and lexicons keywords has a very important role as a good basis to retrieve learning material to provide personalized learning.

3. MODEL OF LO RETEIVAL FOR THE DATABASE COURSE BASED ON ONTOLOGY

During the learning process, personalization can be achieved by retrieval of course material utilizing the course ontology and structure. Two types of retrieval are available:

- Ontology-based retrieval that enables users to see LOs content that belong to topic from ontology based on their search query
- Keywords retrieval that enables user to see LOs content related to keywords relevant to specified search query.

During the learning process learner can combine these two types of retrievals in order to get personalized content satisfying their learning needs. The retrieval is suitable for all learners: (i) non-beginners when learner has some knowledge about the given topic and (ii) beginners when learner is introduced to the topic for the first time. In both cases, learner starts the learning process by ontology-based retrieval. The objective of the ontology-based retrieval is to determine a starting topic. The process of finding starting topic is different for beginners and non-beginners, and it is described below.

Beginner, who learns a course for the first time, starts learning by selecting the highest level topic in the ontological model of the course. Thus, the learner has the ability to retrieve entire knowledge domain for a course. Figure 3 demonstrate the case when a topic from the highest level in the ontology model for the Database course is selected at the beginning of the learning process. In this case, six key subtopic are presented: (i) Information Management Concepts and Fundamentals (IMCF), (ii) Database Query Language (DQL), (iii) Data Organization Architecture (DOAR), (iv) Data Modeling (DMOD), (v) Managing the Database Environment (MDBE), and (vi) Special Purpose Databases (SPDB).

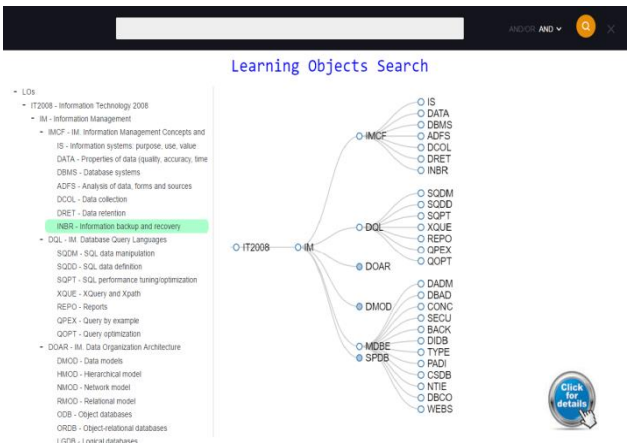

Figure 3: Database ontology in an LOs retrieval system

From the presented ontology, learner selects a topic that wants to learn first. The topic can be chosen by using the textual presentation of ontology (on the left side in Figure 3.), graph presentation (on the right side in Figure 3.) or the list of all topics in the search field (top menu in Figure 3).

An advanced learner who has some knowledge about the topics of the course, and wants to improve knowledge on a certain topic, can directly choose a topic by selecting it from the list of all topics in the search field.

After a topic is selected, the learner has the opportunity to see selected topic's subtopics on the first lower level. The subtopics for "*IMCF IM Information Management Concepts and Fundamentals" topic* from Database course is presented in Figure 4. The subtopics on the next lower levels can also be presented to the learner by clicking on the button "Show related topics", positioned on the right side of topic's name. By showing related topics, the learner has an option to navigate through the ontology until the topics on the lowest level are reached or student estimates that relevant topic for learning is found.

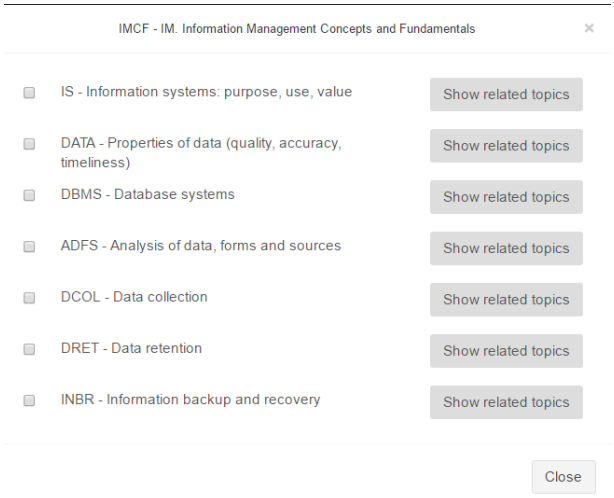

Figure 4: Related topics for the topic "*IMCF - IM. Information Management Concepts and Fundamentals"* on the first lower level in Database course

If a learner wants to see the learning objects for the selected topic in order to read their contents, he/she has to check the field on the left side on the topic name. Learning objects for the topic "*DCOL - Data collection"* from the Database course are presented in the Figure 5.

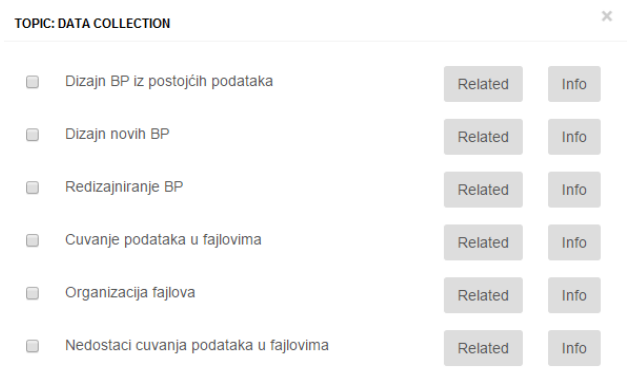

Figure 5: Learning resources for topic "Data collection"

Learner, from this point, can continue learning in different ways:
(i) In order to see the learning resource of a particular LO, learner can click on button "Info" for the relevant content for learning to be presented (Figure 6.)

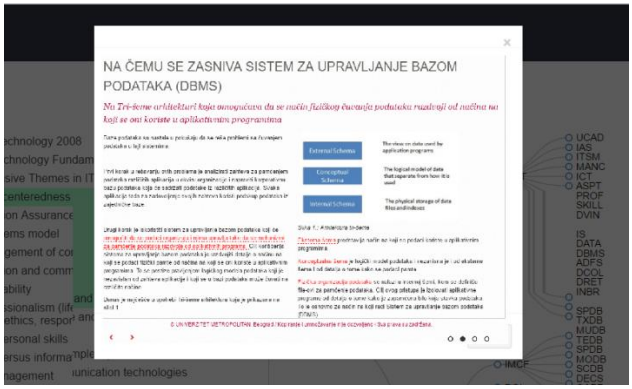

Figure 6: Learning resource for a particular LO

(ii) By clicking on the button "Related", learner has the possibility to see the list of related LOs for the selected LO. In Figure 7, related LOs for learning object "Drop table" is presented. Relations *mandatory* and *optional* i the given example of the Database's LO "Drop table" mean that learner has to learn LOs "Alert table" and "Delete table" before learning "Drop table", without considering a specific order. At the same time learner has an optional LO to view at this point and this LO is "Rollback." In order to see the learning resources for related LO, learner has to double click on it (in Figure 6).

(iii) Learner also has the possibility to return back one level up by checking the field on the left side of the LO's name. By doing this, learner goes back to the starting topic (presented in Figure 4.) and can continue learning process by selecting other topics.
It is recommended that beginners complete learning process by going through all LOs.

Figure 7: Related LOs for LO "Drop table"

On the other hand, when a learner has some knowledge about a topic for which many learning resources are offered, learner has an option to focus only on the topics of personal interest. Then, the previously extricated learning resources by ontological retrieval can be retrieved again by keywords that are specified by learner's queries. In a query, one keyword or many of them combined by logical operations AND/OR must be defined. (Figure 8)

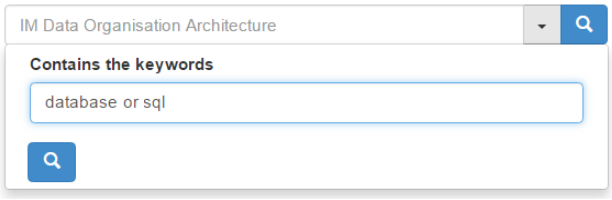

Figure 8: Search by keywords

The keywords search results will be represented as a list of topics (Figure 4) where all relevant topics containing LOs with queried keywords will be presented. These topics may be a part of the Database course and other courses in the curriculum. In such a way, learner has the ability to examine, not only learning resources from the given course but also other topics of interest that are related to it.

4. CONCLUSION

This paper addressed how a model of ontology can contribute to achieving personalized e-learning system and can enhance the learning process. This work proposed ontology-based LOs retrieval model, which was demonstrated on the example of the Database course. Used ontology-based model of retrieval is focused on the reusability and sharing of LOs, which can be easily used for other curricula and courses when needed. Part of the inheritance model should also define methods that will effectively determine whether the prerequisite knowledge is successfully learned.

In particular, the ontology-based retrieval has a possibility of integration with relevant Learning Management Systems (LMS) and shows the potential of ontologies in the application domain of learning material retrieval. Retrieval of LOs stored in LMS is based on existing lexicon of keywords which allows mapping of ontology to corresponding LO content in LMS.

Future work will focus on model improvements and including proposed model retrieval in the context of social learning environment in order to support not only learning activities from the LMS but also collaboration and communication between tutors and learners during the learning process.

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