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An Approach to Integrate Ontologies of Open Educational Resources in Knowledge Based Management Systems

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***Abstract*—There are real needs to integrate types of Open Educational Resources (OER) with an intelligent system to extract information and knowledge in the semantic searching level. The needs came because most of current learning standard adopted web based learning and the e-learning systems do not always serve all educational goals. Semantic Web systems provide educators, students, and researchers with intelligent queries based on a semantic knowledge management learning system. An ontology-based learning system is an advanced system, where ontology plays the core of the semantic web in a smart learning environment. The objective of this paper is to discuss the potentials of ontologies and mapping different kinds of ontologies; heterogeneous or homogenous to manage and control different types of Open Educational Resources. The important contribution of this research is that it uses logical rules and conceptual relations to map between ontologies of different educational resources. We expect from this methodology to establish an intelligent educational system supporting student tutoring, self and lifelong learning system.

***Keywords*—Knowledge Management Systems, Ontologies, Semantic Web, Open Educational Resources.

I. Introduction

TODAY; many of current learning standards (e.g. IEEE, LOM, IMS, SCORM, CanCore) provided students, educators and educational institutes with several educational web systems. Most; if not all of these resources are available and easy in use for end users. Open Educational Resources (OER) are for teaching, learning, and researching. It provides us with free digital resources in many public domains. OER include full courses, course materials, modules, textbooks, streaming videos, tests, software, and any other tools, or techniques used to support access to knowledge. There are many definitions of Open Educational Resources (OER). International institutes and Foundations defined Open Educational Resources according to some purposes and the institutional visions. William and Flora Hewlett Foundation defined OER as: Teaching, learning, and research resources that reside in the public domain or have been released under an intellectual property license that permit their free use and re-purposing by others. Qatar Foundation international (QFI) has supported the development of OER commons Arabic, a site that aggregates standard-aligned open content and incorporates FLOE's.

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In this paper, we expect to gain very important and semantic methodology by integrating the ontologies of OER in a knowledge base system. Our methodology uses a logical rules and conceptual relation to map between different educational Resources as well in multi languages. Technically; ontologies can play this role by integrating educational resources in a logical pool. Moreover, Semantic Web systems will be a safety platform and the environment for end and administrator users. Mapping heterogeneous or homogenous ontologies resources will rich knowledge representations, which will built on the semantic level. On one hand this will reflect on the learning object content, on the other hand, this will give intelligent and more powerful queries to support both the educators and the learners through understanding the curriculums, syllabuses of courses deeply. What we need is a logical and conceptual relation that map between different educational recourses [10].

Ontology and Semantic Web enables online intelligent machine processing to information systems. Different kinds of mathematical logics can be used to manage between concepts, terminologies and rules in educational ontologies which provide the system with advance knowledge. *Machine Learning Ontology* is an expert and very advanced procedure which integrate with our method to map ontologies in a semantic web information system [4]. Further aim of this paper is to establish for new methodologies and open the flour for new research area in integrating the power of ontology and Semantic Web with educational resources. This method can be supported with a logical tools working in the semantic level of a domain [6].

In this paper we will answer the question: *How can ontologies, semantic web, and mathematical logic play a concrete role to establish for a knowledge management system to integrate different Open Educational Resources?*

II. Background about Ontologies

There are many versions of Ontologies definitions, the popular one is: *an explicit, formal specification of shared conceptualization of a domain of interest.* The word ontology was taken from Philosophy. It is derived from the two Greek words (ontos) meaning "to be" and (logos) meaning "world". Ontology is the science or study of being. Ontology is the study of what actually is. This word has become relevant for the knowledge engineering community [7].

III. The Mathematical Ontology Definition

The ontology structure is a 5-type: $O=\{C,R,H^0,rel,A^0\}$, where:

C is a finite set of concepts.

R is a finite set of relations.

H^0 is called concept hierarchy or taxonomy, which is a directed relation $H^0 \subseteq C\times C$, for example, H^0 (C_1, C_2) specifies that C_1 is a sub concept of C_2.

rel relates concepts non-taxonomically, for example, rel (R) = (C_1, C_2) specifies that C_1 and C_2 have relation R.

A^0 is a set of axioms, which is expressed in an appropriate logical language, e.g. first order logic [5].

IV. Ontology Hierarchy and Its Relation with Data Resources

Ontology is suited to represent high-level information requirements. Fig. 1 shows the relationships of ontologies, Entity Relationship models (ER Model), and database schemas. It includes abstract concepts and specifies domain-level constraints that can be used for knowledge-level reasoning [9]. One ontology can be used to define different schemas.

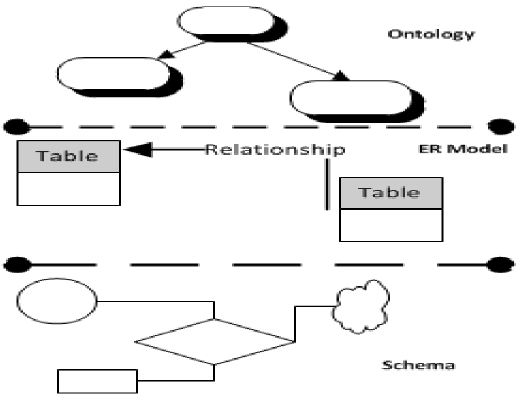

Fig. 1 Ontologies - ER Relationship

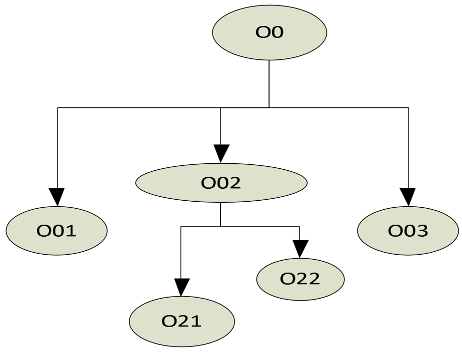

Fig. 2 Ontology Hierarchy

Fig. 2 shows a hierarchy of ontologies. Parent ontology is inherited by child ontologies. Child ontologies understand concepts defined in their parent ontology even though some concepts may have been modified. We expect that every source or application will have an ontology. Similar resources or applications will have similar ontologies which share a common parent ontology. Ontologies closer in the hierarchy will share more knowledge than distant ontologies. The mappings between closer ontologies are expected to be straightforward and simple. The ontology hierarchy should be similar to the classification of domains and sub domains.

V. Semantic Mismatching

In order to solve the problems of semantic mismatches, we will often need to match between different terminologies. In this paper we classified the semantic heterogeneity as follows:

A. Semantically Equivalent Concepts

- Different terms are used to refer to the same concept by two models. These terms are often called synonyms.
- Different properties are modeled by two systems. For example, in one OER system some material has a video material, but the other has not. This heterogeneity is not a bad thing.
- Property type mismatches. For example, the concept 'length' may be in meter or mile.

B. Semantically Unrelated Concepts

Conflicting terms - the same term may be chosen by two systems to denote completely different concepts. For example, apple is used to denote fruit or computer

C. Semantically Related Concepts

- Generalization and specification. One system has only the concept C1, but the other has the concepts of C1, but in different domain. For example is that student in one system refers to all students, but the other only to PhD students [5].
- Overlapping concepts. For example, kids in one ontology means persons aged between 5 to 12 years, but in the other means persons aged between 3 and 10 years, and in yet another ontology, “young persons” means persons aged between 10 and 30 years.
- Different conceptualization. For example, one ontology classifies person as male, female, the other person as employed, unemployed.

VI. How Can Ontologies Work in OER Systems?

Ontology is a formal theory used for explicit knowledge. The main objective of creating ontologies in information systems is to create knowledge model. Generally; ontologies can represent complex relationships between objects, and include the rules and axioms missing from semantic networks. Ontologies describe knowledge in a specific area which often connected with systems for data mining and knowledge management. The concept of OER was to democratize the access of quality education content. OER gather number of educational resources as a public domain or distributed under an intellectual property to provide free use. Courses, textbooks, learning videos, lectures, presentations, teaching software and teaching knowledge materials are all tolls to provide open and free access to knowledge.

Many studies showed that ontology repositories can define, manage, and control knowledge domains. OER resources domain is very important domain which ontology can serve and control the domain management's knowledge. Moreover; ontology is very close to many semantic issues and provide system with intelligent solutions for some complicated relations and then new knowledge as it working on the semantic level of queries and relations [2].

VII. How Does Ontology Clearly Define, Reuse, and Map between Different OER Platforms?

E-learning systems aim to integrate between the educational resources and the power of technology tools to produce new educational environment. The ontology structure is not only to accelerate the queries or giving quality results, it provides users with semantic level of queries that change the structural research. However, the semantic level is working beyond the syntax level. The intelligent solution in matching between different recourses will pave the way to semantic web systems [12]. It also gives solutions for the variety of natural languages in different OER resources that case misinterpretations prone between implementation of Software applications. Ontologies factors and math logical tools in general between ontologies' concepts and relations can be used to define and solve resources mismatching. [1]

VIII. Why Do We Need Mapping OER Ontologies?

Creating mappings is a major engineering work where reuse ontologies are desirable. We differentiate between two kinds of mapping ontologies. Homogenous ontology mapping and Heterogeneous ontologies mapping are the two kinds of mapping when system has ontologies hierarchy in the information system structure. According to the mathematical ontology definition and comparing with 5-types of different ontologies by using mathematical logical concepts can figure roles for primitives mapping [8]. For example; given two Rules R1, R2 belonging to two ontologies O1, O2 respectively, can expressed by a formula using First Order Logic:

$$\forall x \left(\forall y \left(R1(x, y) \equiv R2(x, y)\right)\right).$$

We expect that mapping heterogeneous ontologies will gives important results in bridging bilinguals OER resources. As concepts generally have the same semantic meaning in different spoken languages, then we expect that the logical relations will provide us with output that supports multi languages resources [3].

IX. Open Educational Resources-Semantic Model (OER-SM)

Most Researchers that used ontology in e-learning systems based only onto specific property of the course syllabus or curriculum. Open Educational Resources-Semantic Model (OER-SM) is a methodology aims to work on different layers to create course resources. Fig. 3 shows the methodology diagram. This methodology assumes to use the free OER to build an ontology to extract the best supporting materials fit with the course objective. The free resources on OER provide all academics today with some resources for academic or general courses.

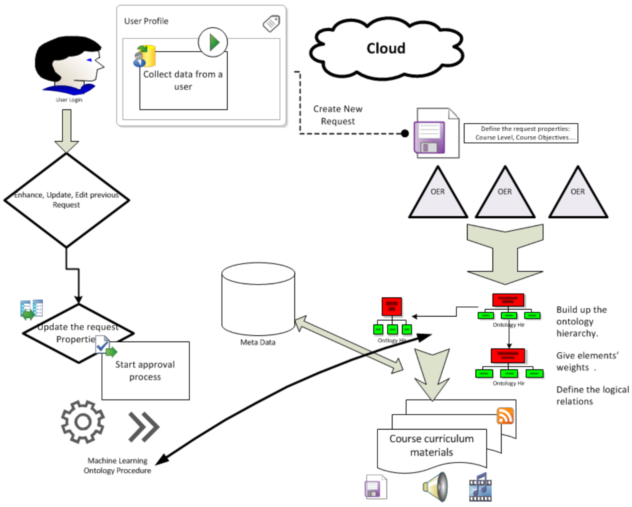

Fig. 3 OER-SM Methodology Diagram

Before we start to proceed the methodology phases, we are on one of two roads: the first one is re-create the ontologies of the system from the beginning. The second one is to use the OER properties that already available to build on the ontologies required.

In our case study, the second solution is much flexible and much easier. As all the OER are contains all needs properties to design the ontologies and its relations.

The OER-SM methodology stream work on the following functionalities: Every user has a user profile. Every user can create one request at least. Any user can update, edit, enhance his old query result. OER-SM refers hat every new query request will go through the full process in two levels: first syntax and then semantic. This paper will only discuss the semantic issue, the subject matter, when any user login, the methodology will differentiate between new request and updating on old request.

A. New User Request

- The system asks the user to define the request properties. A list of objective questions should any user answer to build the query constants.
- OER-SM methodology goes through syntax level directly in OER systems. Then the methodology will shift to the semantic level through the ontology structure that built from the user request and the OER ontology properties and constants.
- In the semantic level; OER-SM compares the user request with the ontology hierarchy.
- Image of new output relations compatible with user requests will be saved in Metadata Analysis.
- Weight for every element and the relations will be saved in the Metadata Analysis. The reason of this weight is to

give priorities and enhance future queries.

- Update the parameters of Machine Learning ontology procedure.

B. Edit User Request

- When a user requests to update, enhance, or edit previous request, OER-SM ask the user to update the request property to build new profile.
- Machine Learning Ontology procedure trigger to compare with closest map ontology profiles to match the request with ontology maps and relations in the Meta Data Analysis.
- Update the Meta Data Analysis.

The output is a set of courses curriculums that support course resources and materials which tailored according the user requests.

C. Define the Logical Relations at the Semantic Level

To define the logical relations between ontologies in the ontologies hierarchy, we will refer to any ontology in the hierarchy as a term. In first order logic, terms are words that can be obtained by applying some rules a finite number of times. Terms consists of variables and constant symbols. As the fact that: if $n \in \mathbb{N}^*$: f is an n-ary function and if $t_1, t_2, t_3 \ldots t_n$ are terms, then the word $f t_1\ t_2\ t_3 \ldots t_n$ is a term. let the hierarchy of the ontologies domain referred by: $o_1, o_2, o_3, o_4 \ldots . o_n$ then, depending on previous fact $f\ o_1 o_2 o_3 o_4 \ldots . o_n$ is a term.

Formulas of the language L in first order logic can be defined on the terms if and only if there exist a natural number $n \in \mathbb{N}^*$, an n-ary relation symbol R, and n term $t_1, t_2, t_3 \ldots t_n$ of the language L such that: $W = R t_1\ t_2\ t_3 \ldots t_n$.

In OER-SM the set of all formulas of the ontology hierarchy domain is $O(L)$, the semantic level of the relations between ontologies will be a sub set of $O(L)$. The semantic sub set will denote by $SO(L)$ which contains:[11]

- All the atomic formulas.
- At least two words O_1, O_2 .
- The words: $\neg O, (O_1 \vee O_2), (O_1 \wedge O_2), (O_1 \Rightarrow O_2)$, and $(O_1 \Leftrightarrow O_2)$.

According to the mathematical definition of ontology, and the case study in this paper that OER-SM mostly be u*niversal closures formula which is a closed formula* in the same time. The *closed formula* is a formula where no variable is free.

In OER-SM system, the *universal closures formula* is the formula of all related variables "concepts" $c_{1,}\ c_{2,}, \ldots . c_{n,}$ of the ontology hierarchy O, where each of the variables "concepts" has at least one free occurrence, then the formula : $\forall c_1\ \forall c_2 \ldots . \forall c_n F$ and all similar formulas obtained by concepts or even axioms will be a *universal closures formula* of the *formula* F.

In heterogeneous ontologies, Prenex forms and Skolem forms have potentials to satisfaction the formals in instructors. Prenex form and Skolem forms allow us to answer questions of the form: "*Is this closed formula universally valid*?" the idea is to reduce the questions, at the cost of changing the relations in the construction, to formulas whose the syntactic construction is relatively simple: Skolem form. The formula is easier to understand when it is in Prenex form, where every first order formula has at least one polite Prenex form.

A *formula* F is a prenex if and only if there exist an integer k, variables $w_1, w_2, w_3, \ldots . w_k$ symbols for quantifiers $Q_1, Q_2, Q_3 \ldots \ldots Q_k$ and a *formula* G without *quantifiers* such that $F = Q_1 w_1\ Q_2 w_2, \ldots . Q_k w_k$G.[11]

The word $Q_1 w_1, Q_2 w_2, \ldots . Q_k w_k$ is then called the prefix of the Prenex formula. The Prenex of the formula is polite if and only if its prefix contain at most one occurrence of each variable.

The Prenex forms and Skolem forms classify and determined the model of terms in one of the following taxonomies: universally equivalent, universally valid, contradictory, satisfiable (non-contradictory), semantically consequence.

Prenex forms and Skolem forms taxonomies can define the terms of the semantic mismatching defined in Section V.

D. How Can Machine Learning Ontologies Work and Reuse the Domain Knowledge in OER?

In this issue we expect that new resources or new domain could be add to the ontologies hierarchy. We still count on ontology's factors, the semantic meaning, and the re-use of domain knowledge. Intermediate and Transmit Ontologies can help to find an intelligent solution to integrate new ontology with ontology hierarchy in a system domain. Moreover; learned ontologies play an intelligent role to classify new ontology in the most suitable location with other ontologies in domain related in the system hierarchy.

X. Conclusion

This paper, we opening the door for educational ontologies and knowledge base systems to work together to approach a methodology in order to:

- Provide educators with package of free course materials.
- Enable open educational recourses to cross matches between course syllabus and curriculums in different educational domains.
- Reuse of the domain knowledge.
- Solving missed and gap information between domains.
- Re-adapting ontologies heterogeneity.
- Find logical solutions for matching educational terminologies, concepts, and taxonomies in different educational domains.
- Linking concepts and terminologies in same dominos for different academic languages.

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