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Ontologies for Interoperability in the eLearning Systems

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Abstract

An essential condition to achieve the efficiency of an eLearning program is of software interoperability. The software interoperability has to be realized on two levels: syntactic level and semantic level. Two software applications can understand each other if they use the same terms or, in case they use different terms; they know the meanings of the terms. This desideratum can be achieved if the softwares use the same ontology or if there can be established a correspondence between their ontologies. In the present paper, there are approached the following subjects: the concept of ontology, techniques and software tools to build ontology, the educational ontologies and the problems related to ontology interoperability.

Key words: *e-learning, ontology, interoperability*

Introduction

In an eLearning programme, there are involved various technologies: databases, web, artificial intelligence, communication, computer networks, word processing, multimedia technologies and web technologies. These technologies are used to develop heterogeneous learning systems that have to collaborate in order to achieve the defined goals. These systems have to communicate and they have to understand the messages that circulate between them. Also, in an eLearning programme, there is shared a huge knowledge among different educational organizations. The main objective of knowledge's sharing consists in developing reusable software, reusable components and learning objects. This objective may be achieved using ontologies.

According to ISO/IEC 2382-01, Information Technology Vocabulary, Fundamental Terms: interoperability is "the capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units".

The goal of the ontologies is to make data more shareable and to facilitate the communication between software applications. Shannon and Weaver [23] proposed a first approach of quantification and measurements of information in A Mathematical Theory of Communication, developing the general model of communication system, as support of the communication. Schramm [22] adapted the linear model of Shannon and Weaver to human communication, introducing a new concept, called "fields of experience" of the sender and receiver, as the dominant factor of messages' understanding by the entities engaged in the communication process. So, it isn't enough to establish a physical communication between applications. Two or more software entities have to cooperate in order to achieve their own goals or common goals. Naiman and Ouksel [18] stated that the semantic conflict exists when the communicating parties use different representations or interpretation of the information that is being communicated. As a rule, there are a lot of heterogeneous software systems, which have to collaborate. An analogy is represented by the modality of communication between two persons speaking two different languages: there may be a third common language, or one of the persons knows the language of the other person, or they use a translator. In any situation, there is a foundation, namely a vocabulary. This vocabulary is represented in information technology by the concept named *ontology*.

In the remaining part of this paper, there are addressed the following subjects: definition of the ontology in the view of computer science; language recommendations to describe ontologies, proposed by World Wide Web Consortium: RDF(S) and OWL; software tools to build ontologies; techniques related to ontology interoperability: ontology alignment; ontology mapping; ontology translation; ontology integration; ontology refinement; ontology unification; algorithms and software tools to automate ontology mapping; ontologies in educational systems; solutions and future research directions are presented.

Using ontology for interoperability allows integration of different resources, developed in different languages, semantic unification of the same term defined in different ontologies. Trausan, Cristea and Udrea [27] stated that ontologies are the binder integrating data base systems, knowledge-based systems and objects-based systems in collaboration-based applications. To realize this requirement it is necessary to establish correspondences between terms from different ontologies. "The ontologies reduce the semantical ambiguities in knowledge's sharing and reusing" [27] In this paper, it is approached the problem of ontologies interoperability and the problem of using ontologies to allow the software applications to be interoperable.

Definition of the Ontology in the View of Computer Science

A well-known definition of the ontology was proposed by Gruber [9] as a specification of a conceptualization. Guarino and Giaretta [10] analyzed the meaning of the term ontology according to seven interpretations: "1. Ontology as a philosophical discipline; 2. Ontology as an informal conceptual system; 3. Ontology as a formal semantic account; 4. Ontology as a specification of a conceptualization; 5. Ontology as a representation of a conceptual system via a logical theory (5.1 characterized by specific formal properties and 5.2 characterized only by its specific purposes); 6. Ontology as the vocabulary used by a logical theory; 7. Ontology as a (meta-level) specification of a logical theory." They drew the following conclusion related to the technical sense of the term "ontology": there are three possible definitions of the term: "ontology is a synonym of ontological theory"; "ontology is a synonym of specification of an ontological commitment"; and "ontology is a synonym of conceptualization".

Sowa [24] defined the term ontology as the product of the study of categories, and the "types in the ontology represent the predicates, word senses, or concept and relation types".

In a simplistic manner, an ontology is defined by a vocabulary of terms interrelated, describing a certain reality. Ontologies are used in the fields of the computer science as artificial intelligence, software engineering, semantic web, language processing. Gruber [9] stated that ontology defines "a set of representational primitives with which to model a domain of knowledge or discourse".

In the field of computer science, ontology is the foundation of describing a domain of interest; it consists in a collection of terms organized in a hierarchical structure that shape the reality. The components of an ontology are, according to Sowa [24] the following: 1.concepts, terms; 2. relations between concepts, terms; 3. properties, attributes of the concepts; 4. rules, axioms, predicates, constraints. Data are modeled by the ontology at the semantic level. Buraga [4] explains that users have to share the same conceptualization of information in order to humans and machines be able to use knowledge in the same mode. "The common vocabulary guarantees the syntactic elements (words, marks) have the same sense both sender and receiver" [4].

In the guide to develop the first ontology, Noy and McGuiness [19] consider that an ontology is composed of classes (called concepts), properties of each concept (slots) and restrictions on slots (facets). Starting from this definition, they define a knowledge base as an ontology together with a set of individual instances.

The main objective of using ontologies is to share knowledge between computers or computers and humans. Computers are capable to transmit and present the information stored in files with different formats, but they are not yet capable to interpret them. To facilitate communication and intelligent processing of information, it is necessary that all actors of the digital space (computers and humans) have the same vocabulary. Ontologies are the foundation of cooperation and the semantical understanding between computers (running a lot of nonhomogenous software programmes) and of the cooperation between computers and humans. Trausan [28] explained the idea that ontologies are the binder, which integrates database systems, knowledge based systems, object systems in collaboration-based applications.

Drawing a conclusion and thinking on the theme of this paper, an ontology represents a set of interconnected terms through a set of relations, described using a set of properties and constraints. These elements are defined with the purpose to generate meanings and interpretations so that to enable two different systems to understand each other.

In the field of computer science, ontologies are classified, varying with their objectives. There are: the top-level (upper-level) ontology, the domain-related ontology, the task-related ontology and the application-related ontology, organized in a hierarchy of the ontologies. A top-level ontology serves to some general objectives. Some examples of these types of the ontologies are: Cyc ontology [32], WordNet ontology and EuroWordNet ontology (these are lexical ontologies) and Sowa's ontology. [37] The ontologies dedicated to an area are called domain-related ontologies or simpler domain ontologies and they are specific of a field. An example of this type is the ontology dedicated to the fields of education. An example is the O4E. [34] A third category of the ontologies is the task-related ontology that consists in an ontology dedicated to some specific tasks. An example is the task ontology for scheduling applications. [20]

Most of the usages of ontologies in the field of computer science are related to knowledge based systems and intelligent systems. These types of ontologies include a small number of concepts and their main objective is to facilitate reasoning. For example, in a multi-agent systems, the knowledge representation is accomplished through a basic ontology, privates ontologies and a knowledge base. Private ontologies of the agents are derived from the basic ontology. The names of the concepts used in private ontologies of the agents are unknown, but their definitions use terms from the basic ontology.

Ontologies Languages: RDF(S) and OWL

RDF (Resource Description Framework) is a W3C recommendation based on XML that offers support for semantic interpretation, to understand the documents existing on web. RDF is used to express the web resources identified through URI (Uniform Resource Identifier). There is a piece of evidence, the fact that a computer program can extract knowledge from documents if the document is marked. RDF is a framework, which allows interoperability between software applications. The documents related to RDF/XML syntax, RDF semantic and RDF Schema can be found on the official site of W3C. [39]

To exemplify the usage of the RDF language, let's consider the statement "The course entitled Graphs Algorithms was written by the author Gabriela and it was designed in multimedia format by the student Adriana and it has enrolled the following students: John, Maria and Peter". The main element of RDF language is a triple of the form resource-property-property value, with the following sense: a resource (subject) has a property (predicate) with a value (object). The RDF description of the statement above is as follows:

```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:dc="http://purl.org/dc/elements/1.1/">
<rdf:Description
       rdf:about="http://informatica.upg-ploiesti.ro/moodle.php">
<dc:Creator> Alice </dc:Creator>
<dc:Title> Graphs Algorithms </dc:Title>
<dc:Format>Multimedia</dc:Format>
<dc:Designer>Ana</dc:Designer>
<dc:Students> </dc:Students>
<dc:Creator>
<rdf:Description
 rdf:about="mailto:xxx@yahoo.com">
<dc:FirstName>Alice</dc:FirstName>
<dc:LastName>Popescu</dc:LastName>
</rdf:Description>
</dc:Creator>
<dc:Designer>
<rdf:Description
rdf:about="mailto:yyy@yahoo.com">
<dc:FirstName>Ana</dc:FirstName>
<dc:LastName>Popa</dc:LastName>
</rdf:Description>
</dc:Designer>
<dc:Students>
<rdf:Bag>
<rdf:li>John</rdf:li>
<rdf:li>Maria</rdf:li>
<rdf:li>Peter</rdf:li>
</rdf:Bag>
</dc:Students>
```

```
</rdf:Description>
</rdf:RDF>
```

The specification used to describe ontologies is RDF Schema. RDF Schema is an extension of RDF language that enables the user to define classes, instances and properties using RDF syntax. With RDFS, it is possible to describe terms and relations between terms of a vocabulary.

To describe classes, RDFS resources are used: *rdfs : CLASS* and *rdfs : subClassOf.*

There are described W3C recommendations about RDF Vocabulary Description Language 1.0: RDF Schema. The fundamental classes of RDF Schema are: rdfs: Resource, rdfs:Class, rdf:Property, rdfs:Datatype, rdfs:Container. The properties are specified with rdfs : properties, domain with rdfs : domain and range with rdfs : range, name with rdfs:label, description with rdfs:commnent. The key concepts of RDF Schema are: class and subclass relations; property and subproperty relations; domain and range restrictions. In the following example, there is presented a part of ontology related to the concepts: teacher and course. (Figure no. 1)

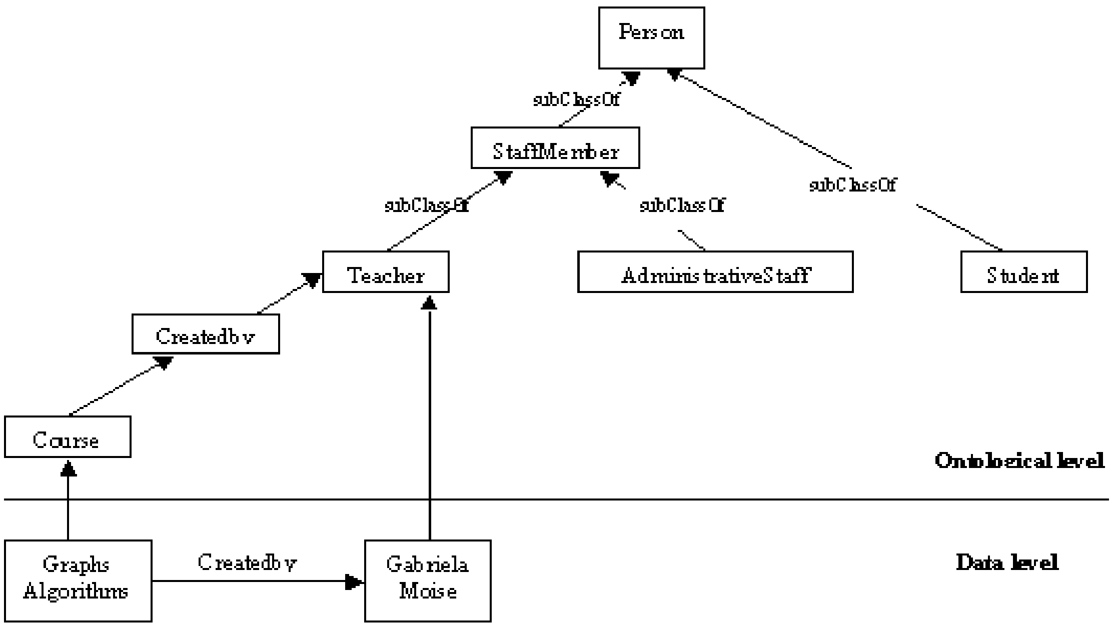

Fig. 1. View of an ontology

OWL is a language dedicated to specify the ontology. There are three distinct species of OWL: OWL Lite, OWL DL and OWL FULL. OWL LITE enables definitions of simple hierarchies of classes and restrictions, such as cardinality 0 or 1. OWL DL enables complex restrictions; it is based on Description Logics. It contains a decidable fragment of First Order Logic. OWL FULL enables to define of more restrictions then OWL DL, facilitates simple reasoning, provides flexibility. The relations between these languages are: *"Every legal OWL Lite ontology is a legal OWL DL ontology. Every legal OWL DL ontology is a legal OWL Full ontology. Every valid OWL Lite conclusion is a valid OWL DL conclusion. Every valid OWL DL conclusion is a valid OWL Full conclusion*." [40]

The most application are based on OWL DL. A capture from a OWL DL description (realized with Protégé [36]) is:

```
<owl:Ontology rdf:about=""/>
<owl:Class rdf:ID="Course">
<rdfs:label rdf:datatype="http://www.w3.org/2001/XMLSchema#string">
Course</rdfs:label>
</owl:Class>
<owl:Class rdf:ID="StaffMember">
<rdfs:subClassOf>
<owl:Class rdf:ID="Person"/>
</rdfs:subClassOf>
<rdfs:label rdf:datatype="http://www.w3.org/2001/XMLSchema#string">
StaffMember</rdfs:label>
</owl:Class>
<owl:Class rdf:ID="Student">
<rdfs:label rdf:datatype="http://www.w3.org/2001/XMLSchema#string">
Student</rdfs:label>
<rdfs:subClassOf rdf:resource="#StaffMember"/>
</owl:Class>
```

Software Tools to Build Ontologies

There is no standard methodology to build an ontology. There were developed a lot of methodologies, according to the modeled domain, the software tool used for this process, the available knowledge expertise and the experts of the domain.

Nevertheless, there are three methods to build an ontology [12]: manual method, automate method and mixed method. Manual method consists in extending an existing ontology or creating a new ontology. In order to extend an ontology, it is used an upper-level ontology (Cyc, WordNet, EuroWordNet). Automated method consists in extracting information from text and organizing it in a conceptual schema. Mixed methods consist in using both methods, that means building an ontology with automated techniques and extending it manually.

Buitelaar and all [3] present the "ontology learning layer cake" to define the tasks needed to develop an ontology. The layers defined by them are: terms, synonyms, concepts, concept hierarchies, relationships and axioms. To define concepts and relationships between them, it is necessary to identify the terms, which refer them, and all synonym terms, in order to eliminate the redundancy of the concepts. The next step is to define concepts and relationships between them and to organize them in a conceptual schema. Finally, in order to obtain facts (using inferences), rules are defined.

Generally speaking, to construct an ontology the following stages are to be followed: Expertise the knowledge domain; Organize the ontology; Fill the ontology; Test the ontology; Commit the ontology.

A lot of software tools (much of them are free) are available to develop ontologies: Protégé, Ontolingua (with Chimaera), DOE- Differential Ontology Editor, Kaon, Apollo, RDFedt, WebOnto, OntoStudio [14] [30].

The Problem of Ontology Interoperability

Techniques Related to Ontology Interoperability

The domain of ontologies is extremely vast. A lot of ontologies were developed, even different ontologies for the same domain. In order to assure the interoperability between software applications, it is necessary to guarantee the interoperability between their ontologies.

Another aspect is that ontologies have to be widely shared. To decrease the effort of building ontologies, it's needed to re-use, to import, export and to process ontologies.

In the literature, there are different techniques related to the ontologies' interoperability: ontology alignment, ontology mapping/matching, ontology translation, ontology integration, ontology refinement and ontology unification. Before defining these operations, there is ought to state different semantic relations between elements of two ontologies: equivalence, disjointness, containment in two directions, overlap.

Equivalence ($\equiv$) is a semantic relation that exists between two elements, representing the same thing (event, object, procedure, etc) of the real in the same context. An identity between two elements means that they have the same syntax and the same meaning. The identity is a strong form of equivalence. An example of equivalence is: (learner $\equiv$ student).

Disjointness ($\perp$) between two elements states that there is no intersection between their interpretations.

Containment ($\subseteq$, $\supseteq$) states "the element in one ontology represents a more specific aspect of the world than the element in other ontology". [21]

An example of the containment relation is: virtual laboratory $\subseteq$ learning unit.

Overlap (o) between two elements from different ontologies states that these elements describe different aspects of the reality, but they are overlapping according to some criteria.

These relations are necessary to represent mapping between ontologies. Example C-OWL mapping provides eight semantic relations: equivalence, containment in two directions, overlap and their negations. (C-OWL is a mapping – aware extension of OWL language, called Context OWL, which allow to represent contextual ontology.)

Ontology Alignment

Alignment is the process of mapping between ontologies possibly transforming them (eliminating the unneeded information or adding new concepts and relations to ontologies). Alignment, as well as mapping, may be partial.

Ontology Mapping

In spite of increasing usage of the ontologies and the creation of the standard languages to define ontologies, there are no common points of view regarding the formalism of the ontologies' mapping.

A large definition of the ontology mapping is according to the morphism of ontological signature. [13] [14]

Let's consider two ontologies (equation 1):

$$O_1 = (S_1, A_1) \text{ and } O_2 = (S_2, A_2) \quad (1)$$

A morphism $f : S_1 \to S_2$ of the ontological signature acquires a map if all interpretations that satisfy the axioms of the ontology O_2 also satisfy all translated axioms of the ontology O_1. This statement can be symbolized as $A_2 \models A_1$.

Ehrig and Sure [7] give the next definition for ontologies mapping:

"given two ontologies A and B, mapping one ontology with another means that for each concept (node) in ontology A, we try to find a corresponding concept (node), which has the same or similar semantics, in ontology B and vice versa."

The process of ontology mapping is defined as "a formal expression that states the semantic relation between two entities belonging to different ontologies. " [1]

According to the definitions of the components of an ontology as presented in Ontology Interoperability -Draft version 0.3.2, to define a map between two ontologies means to establish a correspondence between the components of the ontologies, respecting "the same or the closest intended meaning". [38]

Ontology Translation

Ontology translation is used in the tasks consisting in reusing the ontology (or a part of the ontology) as presented in Ontology Interoperability -Draft version 0.3.2, "using a tool or a language that is different from those ones in which otology is available; a good translation will leave the semantics of the translated ontology unaltered, or as closest as possible, to the original". [38]

Ontology Integration

Ontology integration is the process of finding common parts of two (or more) ontologies (A and B) and developing a new ontology (C) that allows interoperability between two systems based on the ontologies (A and B). The new ontology C may replace the ontology A or the ontology B or me be used as "intermediary" [24] between the systems based on the ontology A or on the ontology B, respectively.

Depending on the amount of changing necessary, the levels of integration can be distinguished as follows: alignment (minimal changes), partial compatibility and unification (requires major changes that can lead to total interoperability).

Ontology Refinement

Refinement is the process of mapping between two ontologies so that every concept of one ontology has an equivalent in the other ontology. A primitive of one ontology may be equivalent to a non-primitive of the other ontology.

Refinement defines a partial ordering of the ontologies: if the ontology no. 2 is a refinement of the ontology no. 1 and the ontology no. 3 is a refinement of the ontology no. 2 then the ontology no. 3 is a refinement of the ontology no. 1.

Ontology Unification

Ontology unification is the process of aligning all concepts and relations of two ontologies, fact that "allows any inference or computation expressed in one to be mapped to an equivalent inference or computation in the other." [24]

The unification process is the refinement process in both directions.

Algorithms and Software Tools to Automate Ontology Mapping

Nowadays, algorithms used to automate ontology mapping are built based on the multiple strategies. These strategies analyze the information included in an ontology and select the lexical features, the structural knowledge, the constraints of the entities' instances and computes (using heuristics) all these inputs in order to result a semantic correspondence between entities of the ontologies.

The researches have proved that usage of the combining strategies leads to the good results regarding the ontology mapping problems. [2, 14, 16, 26]

Some algorithms are:

- HCONE-merge method, developed by Kotis, Vouros, Stergiou, [14]. This technique uses the WordNet as an intermediate ontology and Latent Semantic Index method to associate the ontologies' concepts with WorldNet senses;
- iRiROM algorithm uses combined strategies: instances-based strategies, name-based strategies, entities' description based-strategies, name path-based strategies, taxonomy context-based strategy and constraints-based strategy. All these strategies are combined in a formula with sigmoid function, associating to each strategy a weight factor. This algorithm is developed by Tang, Liang and Li [26];
- Dynamical map ontology algorithm developed by Bouzeghoub and Elbyed [2] combines different similarity measures: linguistic similarity, structural similarity and rule-based similarity;
- Neural Network-based algorithm: there are developed several algorithms, such as those proposed by Mao, Peng, and Spring [16]; and by Hariri, Abolhassani, Sayyadi [11];
- Artificial Intelligence techniques, Data Mining-based algorithms.

There are several software tools, which enable the ontology matching. Most important are:

- CHIMAERA supports merging multiple ontologies, implemented by KSL, Stanford University [31];
- FCA (Formal Concept Analysis) Merge is an ontology bottom-up merging tool, proposed by Stumme and Mädche [25];
- IF-map is an automatic method for ontology mapping based on the information flow, developed by Kalfoglou and Schorlemmer [13] [33];
- ONIONS methodology (Gangemi, Pisanelli, Steve) [8];
- PROMPT enables ontology comparison and merging [35];
- OntoMerge is a semi-automated method, developed by McDermott, Dou, Qi [6].

An example of ontologies' mapping is presented in Figure 2.

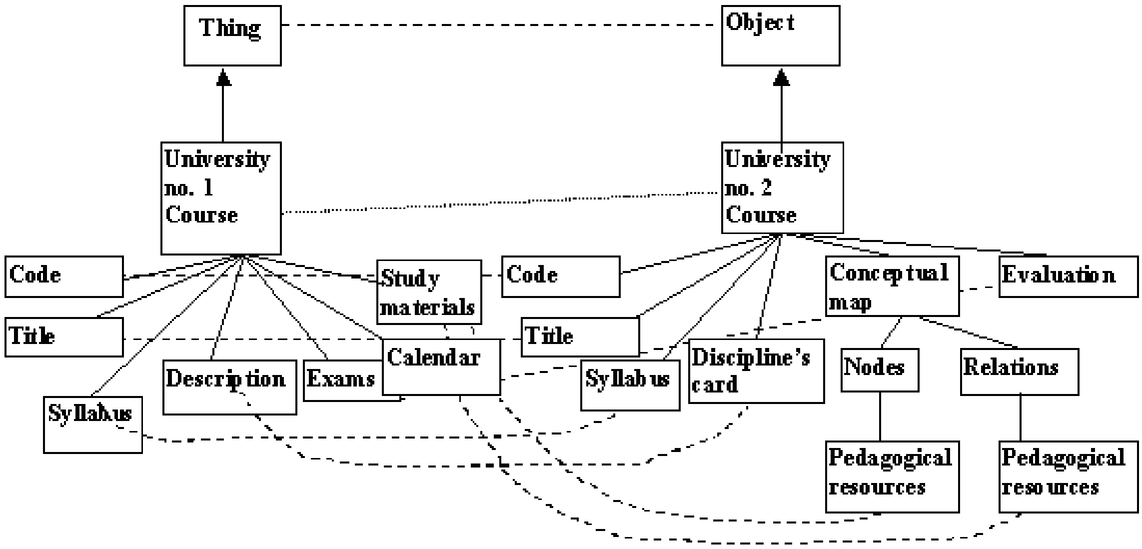

Fig. 2. Ontologies mapping example

Ontologies in Educational Systems

Ontologies' usage in educational systems may be approached from various points of view: as a common vocabulary for multi-agent systems, as a chain between heterogeneous educational systems, ontologies for pedagogical resources sharing or for sharing data and ontologies used to mediate the search of the learning materials on the Internet.

The abstract specification of a system is composed of functional interconnected elements. These elements communicate using an interface and a common vocabulary. The online instructional process can be implemented successfully using artificial intelligence techniques.

Sophistical software programs with the following features give the intelligence of the machine: : adaptability, flexibility, learning capacity, reactive capacity, autonomy, collaboration and understanding capacity. This approach enables to solve the complexity and the incertitude of the instructional systems.

The main categories of intelligent instructional systems are:

- Intelligent Tutoring Systems;
- Intelligent Learning Environments;
- Pedagogical Agents;
- Intelligent Computer Assisted Instruction.

The personalized instructions represent the core of the intelligent learning models. Computer's technologies offer the opportunity to develop flexible intelligent instructional systems.

An intelligent learning system based on a multi-agent approach consists in a set of intelligent agents, which have to communicate. They collaborate through messages. Software agents can understand and interpret the messages due to a common ontology or the interoperability of the private ontologies. A multi-agent system, proposed by Moise [17] contains six software intelligent agents: the communication agent, the exam agent, the tutor agent, the pedagogic agent, the interface agent and the supervisor agent. The agents cooperate, they have distinct goals and are managed by the supervisor agent. The supervisor agent coordinates the whole educational process. All agents use a common ontology, mainly composed by the student's model, course's model, teacher's model and instructional model.

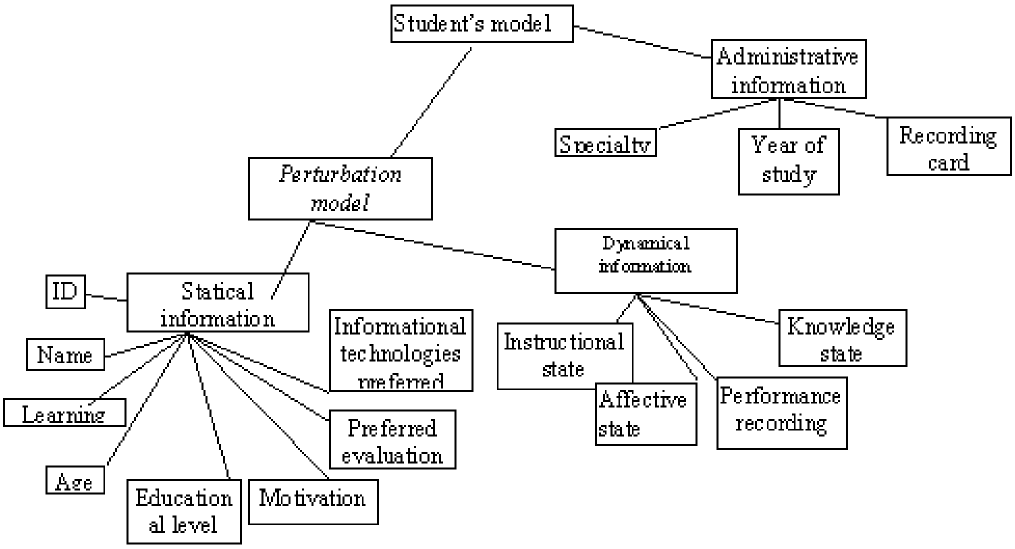

Fig. 3. Student's model

Ontologies are the linking chain between heterogeneous educational systems. Nowadays, there are developed numerous instructional systems, dedicated to different domains: art studies, science studies and economical studies. The ontologies' interoperability techniques enable to build instructional collaborative environments and to share data.

Wang [29] defined a learning object as "a unit of digital resource that can be shred to support teaching and learning". He stated that the ontology allows people "to share common understanding of the subject domain of learning objects". So, in this case, the ontology has the role of a conceptual network, containing related learning objects. There is available a software, system called LOSON (Learning Objects Sharing through the Ontology) which "enables the learning objects' access according to the ontological knowledge structure for pedagogical design". [29]

One of much interest is the project O4E, developed by Dicheva and all [5]. They present the expectations of the usage of ontologies in education and of their building for education. Ontologies are used in education from two perspectives: a technological perspective and an application perspective. Concerning the technological perspective, there are three branches: KR technology, IR technology and Web Semantic technology. With respect to the applicative perspective, there exist two branches: cognitive tool and type of knowledge. The ontology can be developed automatically, semi-automatically or manually by using different standards and languages (like SCORM or LOM).

The communication process in the online instructional environment has three dimensions: human-machine communication, machine-machine communication and human-human communication. The role of an ontology is to facilitate the communication (meaning cooperation and integration) between two or more applications and between software program and users. The role of the ontology is to assure the semantic understanding between all actors (software and users).

Solutions and Recommendations

Most of the algorithms used in ontologies mapping use of a method to measure the similarity distance or the semantic distance between entities of the ontologies. These values are computed using a combinative strategy.

A good strategy is to include the automatic learning technique in the algorithms dedicated to ontologies' mapping. One may begin with a supervised strategies and continue with a reward learning technique. The field of artificial intelligence provides a lot of techniques and strategies to implement automatic software application dedicated to ontologies' mapping.

My research in this area is focused on the implementation of artificial intelligence techniques in the process of ontology matching. These techniques can be: neural networks, , reward algorithms, fuzzy theory and Bayesian network.

The process of establishing perfect correspondences between ontologies is a difficult one, as till now this process can't be completely automated. Human intervention is absolutely necessary. A viable solution is to use an existing ontology and to adapt it the requirements of the software applications. The usage of a global ontology (that's means a huge ontology) in all domains is not a solution.

Semantic Web is with no doubt the present and the future of the Web. This offers a reach integration and interoperability of data among virtual communities. Educational systems tend to extend beyond any organizational boundaries.

The effort of building pedagogical resources is huge. The ontologies are the perfect tools which enable sharing and reusing learning units. The advantage offered by usage of the interoperable ontologies is not only that of saving financial and time effort, but also that of enabling users to build large virtual collaborative communities. The large educational interconnected systems offer great opportunity to develop the instructional areas. Future research directions have to be oriented to create large educational virtual communities. In order to accomplish this desideratum, researches should be oriented to standardize ontologies and to make them available to the educational organizations.

Conclusions

In the educational systems, especially in the web based educational systems, ontologies are used by different applications: multi-agent based applications, collaborative environments, web services, information acquisitions, sharing and discovery tools. The matching tasks of ontologies are the core task of ontology interoperability. Heterogeneous educational systems have to communicate each other and to other applications.

The research effort is oriented to the standardized the description languages of the ontologies and to build algorithms in order to automates ontologies' matching. The software application's integration is the main subject of the ontologies. Even if two systems use the same set of terms, it is possible that they do not agree on a certain item of information. The key is that software systems have to use the same domain's conceptualization or to match their domain's conceptualization.

There are two approaches about interoperability of software systems: the former approach consists in matching the particular ontologies of different systems, whereas the latter consists in using a common ontology. A combinative method is used, especially in the field of multi-agent based applications. The relationships between ontologies leads to defining an ontology' network, which can be used in the web-based applications. Ontologies offer a great potential in the repository of learning objects. Nowadays, there is an abundance of pedagogical resources in diverse formats: video, audio and text. Managing these resources is possible because of the ontologies. Searching operations can be realized because of the metadata (author of the resource, title, keywords, etc.) and the semantics of the content.

The researchers anticipate an increasing usage of ontologies, in the conditions of raising both the quantity of knowledge and the request for knowledge. This paper is thought as a survey in the problematic of ontologies for interoperability, focusing on their application in the educational systems.

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Ontologiile în scopul interoperabilității în sistemele eLearning

Rezumat

Interoperabilitatea software reprezintă o condiție esențială pentru a defini eficiența unui program elearning. Interoperabilitatea software se definește pe două niveluri: nivelul sintactic şi nivelul semantic. Două aplicații software pot comunica dacă utilizează aceeaşi termeni sau înțeleg semnificația termenilor. Acest deziderat poate fi realizat dacă software-urile utilizează aceeaşi ontologie sau se poate stabili o corespondență între propriile ontologii. În lucrarea de față, sunt abordate următoarele subiecte: conceptul de ontologie, tehnici şi instrumente software pentru a construi ontologii, ontologii educaționale şi probleme privind interoperabilitatea ontologiilor.