E-Learning Developing Using Ontological Engineering

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Abstract: - One of the most important prerequisites in base plan for long-term development of all countries is high education level in society what includes e-learning studies. The time is coming when global tasks could be solved only with communication and learning in world level.

Ontological engineering have become an efficient methodology for knowledge representation and management in many domains and tasks. Ontology design, approaches and methodologies are very important issues for building ontologies for specific task. This paper presents the application of the ontological engineering methodology in e-Learning domain. There is the development of two web-based ontologies in the area of artificial intelligence technology. The first one is the "Artificial Intelligence in Education" ontology and the second is 'Expert Systems" ontology. The developed ontologies were encoded in OWL-DL format using the Protégé-OWL editing environment.

The ontological engineering methodology is widely used in many domains of computer and information science, cooperative information systems, intelligent information integration, information retrieval and extraction, knowledge representation, and database management systems. Several attempts introducing universal ontology for E-Learning materials have had only modest success.

Key-Words: - artificial intelligence in education, e-learning, knowledge management, ontological engineering

1 Introduction

Knowledge management includes acquiring or creating knowledge, transforming it into a reusable form, retaining it, and finding and reusing it. There is an important change of educational focus from remembering large amounts of knowledge to ability to solve problems and quickly find necessary information. It makes important influence for changing learning methods from traditional lectures and presentation materials to active use and structure of information. Growing importance of learning games, analysis of situations and research will take part in learning methods [1]. E-learning courses have to serve various learner groups and can be presented in many different forms. There are novice learners, intermediate and advanced up to experienced students. Furthermore, E-learning courses can be attended by dependent or independent learners who study full-time or part-time. On the other hand E-learning is based on certain prerequisites, such as management, culture, and IT [2]. Abreast evolution IT and Web technologies E-learning acquires a great popularity – it is useful in tertiary education, e.g. universities, also in lifelong learning scope.

In order to look in some existing materials and use them or adapt them for using in educational work, most of the educators are working to create new materials and put them into web – with strong probability that there are a lot of similar materials putted into web by other people. But most of those materials has a short lifetime - information is often lost, duplicated or remains unused. Marking content with descriptive terms, also called keywords or tags, is a common way of organizing content for future navigation, filtering or search.

By sharing and reusing the E-learning materials on the internet there are two typical problems. A typical search problem is - given a sub list of properties and tags, find a document. This problem can be solved by using more or less popular searching algorithms on internet. A typical annotation problem is dual one - given a document and a sub list of properties, find some appropriate tags for it to make this document maximally available for sharing and reusing.

With the progression of E-learning in society there is exponential growth of E-learning resources or knowledge items on the internet observed. It is becoming increasingly difficult to find and organize relevant materials. Most of E-learning materials are created for some specific course, event etc. The authors of those materials are in general lecturers, professors, and teachers – people working in educational sphere and having interests to share their e-learning materials as wide as it is possible for all the people who can take some benefit of them. Teaching staff creating e-learning materials and placing them into web are glad if their work helps some another educator to make new materials or use existing materials in lectures. But it is fairly difficult to find later e-learning materials placed in the web. It is difficult also for authors of those materials; not to mention for people who haven't even new about existing similar materials into web. One of the idea is using ontology for this purpose.

Ontologies provide a common vocabulary of an area and define, with different levels of formality, the meaning of the terms and the relationships between them. Ontological Engineering refers to the set of activities that concern the ontology development process, the ontology life cycle, the methods and methodologies for building ontologies, and the tool suites and languages that support them. During the last decade, increasing attention has been focused on ontologies [3, 4, 5]. The main benefits of using ontological engineering approach are: (a) to share common understanding of the structure of information among people or software agents (b) to enable reuse of domain knowledge (c) to make domain assumptions explicit (d) to separate domain knowledge from operational knowledge (e) to analyze domain knowledge.

Authors of this paper are using some specific terms and definitions. It is significant to arrange about meaning definitions used through presented paper. Knowledge item is material in textual format used in E-learning. Tags are free forms textual labels used for knowledge items. Tags is often used in Internet for allowing people to select and organize information (Gmail), links as bookmarks (del.icio.us), photos (Flickr), blogs (Technorati) and research papers (CiteULike), they can also be a tool for social navigation, helping people to share and discover new information contributed by other community members. Tagging algorithm defines as algorithm what analyses given document (E-learning material) and in compliance with results of analysis suggest most accordance tags.

Tags are taken from either an open or a closed vocabulary, but to improve user experience and consistency, the tagging service offers a user a list of suggested tags. To improve quality of suggestions, it also broadcasts request to other similar tagging services. Whenever the user picks most appropriate suggestions or writes in his/her own, this data is stored back to some of the tagging. We can speak about tagging service that the server on which is working tagging algorithm.

Ontologies may be categorized according to the domain they represent or the level of detail they provide. General ontologies represent knowledge at an intermediate level of detail independently of a specific task. Domain ontologies represent knowledge about a particular part of the world, such as medicine, and should reflect the underlying reality through a theory of the domain represented. Finally, ontologies designed for specific tasks are called application ontologies. Conversely, reference ontologies are developed independently of any particular purpose and serve as modules sharable across domains. At present, there are applications of ontologies with commercial, industrial, academicals, biomedical, and research focuses [6,7,8].

On the other side, the term ontology is widely used in many domains of computer and information science: in cooperative information systems, intelligent information integration, information retrieval and extraction, knowledge representation, and database management systems. Many different definitions of the term are proposed. One of the well-known definitions of ontology is Gruber's [9]. There are some useful and widespread ontologies describing generic objects - Web resources (Dublin Core), people (VCard, FOAF), discussion forum comments (SIOC). Several attempts introducing universal ontology for E-Learning materials have had only modest success. But there are a lot of ontologies and taxonomies, using for solutions of E-learning content managing problems in concrete areas or for concrete goals [10, 11, 12].

In this paper we focus our discussion around the usage ontological engineering approach in the domain of e-learning course development.

The goal of the research is to model collaboration between distributed tagging services, storing knowledge items such as bookmarks or index-cards and promote sharing and reusing of them using ontology.

Authors developed a collaborative model for distributed tagging information referring E-learning materials. System given in this paper provides an ontology that operates not just on one server but can exchange information with a number of similar servers calling tagging services.

In model considered in this paper ontology helps to receive knowledge items from users and assigns each item to one or more categories by attaching one or more tags. Each service is used by a definite E-learning materials developing community which situated separately. Collaborative model is intended to serve a wide public having diverse interests and needs. Hence E-learning materials can later be find and retrieved by users according to needs or interests.

Section 2 discusses the perspective of computer science in ontological engineering. Section 3 presents different ontologies in intelligent education systems. Section 4 introduces an overview of the research issues for building ontologies. Section 5 presents the developed AI-Ed ontology and expert systems ontology respectively. Section 6 defines proposals for model. Section 7 contains discussion. Finally section 8 concludes the work.

2 Ontological Engineering from the Computer Science Perspective

Ontologies are used in the fields of computer science as artificial intelligence, software engineering, semantic web, language processing. Gruber [13] 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 ontology are, according to Sowa [14] 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. In the guide to develop the first ontology , Noy and McGuiness [15] 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 human. Computers are capable to transmit and present the information stored in files with different formats, but they are not yet compatible 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 programs) and of the cooperation between computers and humans. Trausan [16] explained the idea that ontologies are the binder, which integrates database systems, knowledge based systems, object systems in collaboration-based applications.

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 [17], WordNet ontology and Euro WordNet ontology (these are lexical ontologies) and Sowa's ontology[18]. 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 [19]. 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.

In our model are three categories of objects considering - a potentially infinite domain of documents or knowledge items, a finite and extensible list of their properties, and for each property – it's possible values or tags, which also come from a finite and extensible list; i.e. tag vocabulary for each property is controlled.
Given a property, there is a bipartite graph relationship (many-to-many) between documents and possible tags.

Collaborative tagging is a practice of allowing anyone freely attach tags to content. It allows sharing and reusing knowledge items for people from different communities, having access to tagging services. Of the web collaborative tagging has grown popular, as it is finding most useful when there is nobody in the "librarian" role or there is simply too much content for a single authority to classify [21].

The model provides faceted browse to alleviate work with system also for people who haven't daily experience of making data bases.

3 Ontologies in Intelligent Educational Systems

Ontologies' usage in educational systems may be approached from various points of view: as a common vocabulary for multi-agent system, 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: (a) Intelligent Tutoring Environments (b) Intelligent Learning Environments (c) Pedagogical Agents (d) 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 [22] 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.

4 Research Issues for Building Ontologies

Ontologies are now ubiquitous in many information-systems enterprises. They constitute the backbone for the Semantic Web as well as they are used in all of e-activities domains (e.g.e-Government, e-Learning, e-Health, e-Business, ect..). As a result, developers are designing a large number of ontologies using different tools and different languages. These ontologies cover unrelated or overlapping domains, at different levels of detail and granularity. Such wide-spread use of ontologies inevitably produces an ontology-management problem: ontology developers and users need to be able to find and compare existing ontologies, reuse complete ontologies or their parts, maintain different versions, and so on. Also Gavrilova et al. develop a methodology where the design of ontology is evaluated by assessing its structure with several quantitative metrics [23].

4.1 Methodologies

Ontological engineering is still relatively immature discipline; each research group employs its own methodology. Ontology methodologies differ according to the strategy of identifying concepts. The well known three possible strategies for identifying concepts are: (a) bottom-up from the most concrete to the most abstract; (b) top-down from the most abstract to the most concrete; and (c) middle-out from the most relevant to the most abstract and most concrete. The last one is the most common strategy.

4.2 Ontological Languages and Tools

A great range of languages have been used for implementing ontologies during the last decade: *Ontolingua, LOOM, OCML, FLogic, CARIN, OKBC, Telos, Cycl* [24, 25, 26] Many of these languages had been already used for representing knowledge inside knowledge-based applications, other ones were adapted from existing knowledge representation languages, and there is also a group of languages that were specifically created for representing ontologies. These languages (which called "traditional" languages) are in a stable phase of development, and their syntax consists of plain text where ontologies are specified (many of them have a Lisp-like syntax).

Recently, Web-based ontology specification languages have been developed in the context of the World Wide Web (and have had great impact in the development of the Semantic Web): *RDF, RDF Schema, SHOE, XOL, OML, OIL, DAML+OIL and OWL.* [27] Their syntax is based on *XML*, which has been widely adopted as a 'standard' language for exchanging information on the web, except for *SHOE*, whose syntax is based on HTML. From all these languages, RDF and RDF Schema cannot be considered as ontology languages, but as general languages for the description of metadata in the web. Most of these "markup" languages are still in a development phase; hence, they are continuously evolving.

At the same time as these ontology languages have been developed, tools have emerged for creating, editing and managing ontologies written in the various languages *Protégé 2000*, Ontological tools usually provide a graphical user interface for building ontologies, which allows the ontologist to create ontologies without using directly a specific ontology specification language. *OntoEdit,OilEd , WebODE, Ontolingua , Ontosaurus , LinkFactory.*

4.3 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 need to re-use, to import, export and process ontologies.

In the literature, there are different technologies related to the ontologies' interoperability,namely; ontology alignment, ontology mapping matching, ontology translation, ontology integration, ontology refinement and ontology unification[28,29,30].

*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.

*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 the is different from those ones in which otology is available; a good translation will leave the semantics of the translated ontology unrelated, or as closest as possible, to the original.

*Ontology integration***:** Ontology integration is the process of finding common parts of two (or more) ontologies (A and B) and developing a new ontology © that allows interoperability between two systems based on the ontologies (A and B). The new ontology V may replace the ontology A or the ontology B or may be used as "intermediary" [8] 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 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”[8]. The unification process is the refinement process in both directions.

4.4 Ontology Validation

Validation is the process to determine whether a work product satisfies its requirements. One should always validate ontology, but the amount of effort one should devote to validation depends on the size of the community being served by the ontology [8] Validation can be performed after the ontology has been developed, but it is usually better to validate while the ontology is being built. There are a several techniques that can be used to validate ontology: (a) Verify the fulfillment of the purpose, (b) Check that all usage examples are expressible, (c) Create examples that are the consistent with the ontology, and determine whether they are meaningful, and (d) Check that the ontology is formally consistent. The ontology validation process according to Anquetil et al.[31] can be described using two main criteria: 1) quality of the ontology itself; and 2) relevance to the field, i.e., the usefulness of the concepts for software maintenance. Quality of the ontology is validated based on the following criteria: 1) consistency; 2) completeness; 3) conciseness; 4) clarity; 5) generality; and 6) robustness.

4.5 Ontology Evaluation

Kamthan and Pai [32] perform ontology evaluation based on the following criteria: 1) completeness; 2) correctness; 3) decidability; 4) maintainability; 5) minimal redundancy; 6) rich axiomatisation; 7) efficiency. A more formal ontology evaluation method, proposed by Obrst et al.[33], includes: 1) development of an ontology and ontology tool competition; 2) principled certification of ontologies by a reviewing organization or community; 3) the development of an ontology maturity model

Developing a Web-Based “Artificial Intelligence in Education” Ontology

The methodology of developing a web-based AI-Ed ontology is as follows: (1) Organizing and scoping: establishes the objectives and requirements. The scope defines the boundaries of the ontology. (2) Data collection: the raw data needed for ontology development is acquired. (3) Data analysis: the ontology is extracted from the results of data collection. The objects of interest in the domain are listed, followed by identification of objects on the boundaries of the ontology. Relations between objects can be identified, adding instances to the ontology. (4) Initial ontology development: a preliminary ontology is developed (i.e. classes, relations and properties). (5) Ontology refinement: the initial development is iteratively refined.

4.6 Organization and Scoping

The field of artificial intelligence in education (AI-ED) has become the most challenging area in the last several years. The goal of the AI-ED is to deliver educational knowledge-based systems used in real teaching, learning and training. Figure 1 shows the disciplines and research areas of the AI-ED based on the analysis of the topics of the World Conferences on “ Artificial Intelligence in Education (AI-ED)”, which held during the period 1993-2007. From this figure it can be seen that the research in the field of AI-ED consists of seven main areas, namely: Intelligent Educational Systems (IES), Teaching Aspects, Learning Aspects, Cognitive Science, Knowledge Structure, Intelligent Tools, Shells and Interfaces. The main systems of the IES are Intelligent Tutoring Systems (ITS), Educational Robotics and Multimedia Systems.

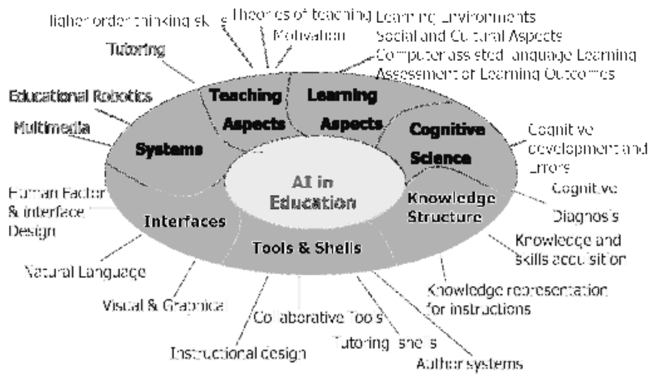

Fig. 1 Artificial intelligence in education (AI-ED).

4.6 Data Collection

In this stage, the knowledge is collected, codified, organized and arranged in a systematic order. This process of collecting and organizing the knowledge is called knowledge engineering. It is the most difficult and time-consuming stage of any ontology development process. In this respect, the data is collected from the following resources: (1) Artificial Intelligence a Modern Approach, Stuart Russel and Peter Norvig [34], (2) Proceedings of Artificial Intelligence in Education, Jim Greer [35].

4.7 Data Analysis

In this stage, the general features of the ontology are extracted from the results of data collection. In this stage ,the following operations are determined.(1) the “objects” of interest in the domain are listed, followed by identification of objects on the boundaries of the ontology.(2) “relations” between objects are identified.(3) adding ”instances” to the ontology. Figure 2 shows general topics of research in AI-ED.

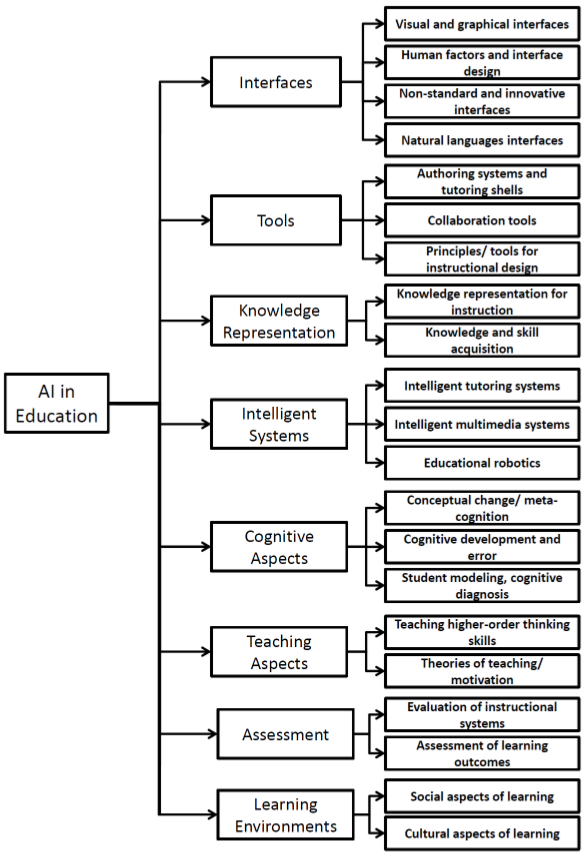

Fig. 2. Areas of Research in Artificial intelligence in Education.

4.8 Developed Ontology

Figure 3 shows the developed AI-ED ontology encoded in OWL-DL format using the Protégé-OWL editing environment. From this figure it can be seen that the developed ontology has 8 main sub-classes (1) machine learning; (2) natural language processing; (3) theorem proving; (4) computer science; (5) games; (6) speech recognition; (7) theory of computation; (8) action and perception; (9) problem solving; (10) planning; (11) robotics; and (12) education; (13) knowledge engineering; (14) computer vision; (15) connectionist models; and (16) cognitive modeling.

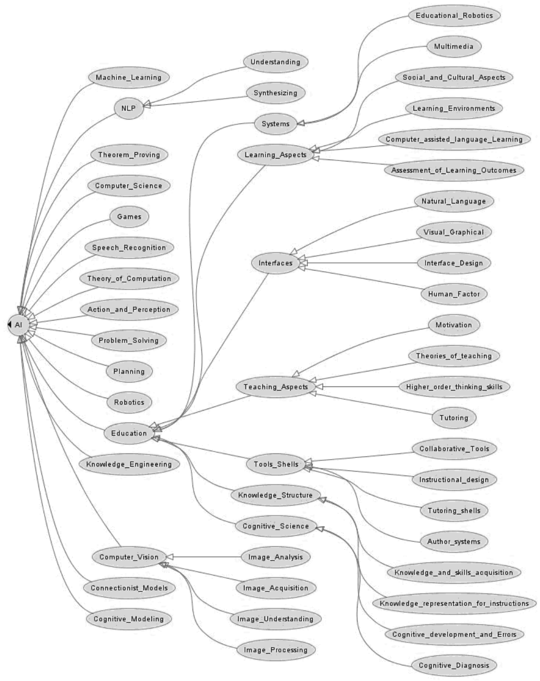

Fig. 3. Developed “AI Ontology” Encoded in OWL-DL format using Protégé OWL Editing Environment.

5 Developing a Web-Based “Expert Systems” Ontology

There are some e-learning models developed by other researchers [36,37]. The Student Models (SMs) should not only represent the student's knowledge, but rather they should reflect, as faithfully as possible, the student's reasoning process [38]. Expert system is a consultation intelligent system that contains the knowledge and experience of one or more experts in a specific domain that anyone can tap as an aid in solving problems . The most commonly systems are rule-based expert systems (RES) and case-based expert systems (CES). In RES the knowledge base stores the knowledge in the form of production rules (if-then statements). The inference engine contains a set of formal logic relationships which may or may not resemble the way that real human expert reach conclusions. CES uses case-based reasoning methodology in which the system can reason from analogy from the past cases.

Data is collected from the following sources: (1) Crash Course in Artificial Intelligence and Exert Systems[39] and (2) Artificial Intelligence Structure and Strategies for Complex Problem Saving [40]. Figure 4 shows the semantic net of expert systems (identifications of main object of interest and relationships between objects). Figure 5 shows the developed expert systems ontology encoded in OWL-DL format using Protégé OWL editing environment. In this ontology four main super-classes namely (a) expert system tools; (b) knowledge base; (c) inference mechanism; and (d) user interface. Expert system tools have four subclasses: (a) programming languages (b) knowledge-engineering language; (c) system-building aids; and (d) support-environment tools.

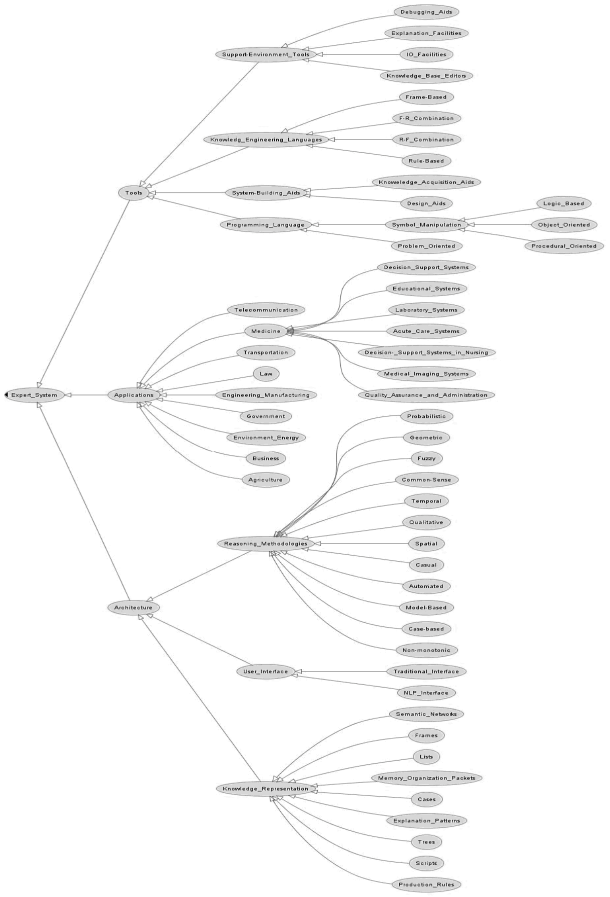

Fig. 5. “Expert Systems Ontology” Encoded in OWL-DL format using Protégé OWL Editing Environment.

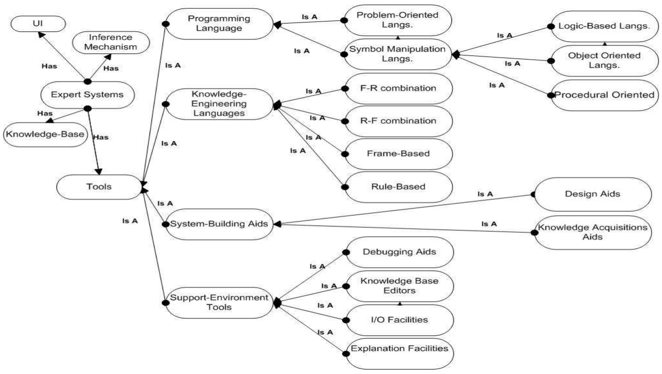

Fig. 4. Semantic Net of Expert Systems

6 PROPOSALS FOR MODEL

There are a lot of manners for solving above mentioned typical search and typical annotation problems. Unfortunately those solving can’t be fully used in searching and annotation because into existing applications in general some border cases are well studied and incorporated. They are poorly usable for sharing, finding and reusing e-learning materials which are mostly not satisfying those border cases. Considered model is developed on purpose to counterbalance border cases mentioned bellow:

- Very large amount of indexed documents (Google, de.icio.us) vs. a small amount of indexed documents e.g. manual annotations, ontology reasoning for certain subject areas. Some ontology examples and descriptions are given in [41,42,43]. Authors are interested in a number of documents, which is large (10-100 thousand). They cannot be processed with full text search and something like Google rank alone; they also cannot be quickly and consistently annotated by a single term either.
- Very many information servers, such a global Web with documents and their keywords, or just one server to store annotations. We looking into some servers, where each of them represents community of people with the certain interests – educational institutions, and model their collaboration.
- Almost no collaboration between the content developers vs. content developers complying with certain ontology e.g. developed for some projects, like IMS. Model is developed to supply collaboration between authors of knowledge items despite own interests of each separate person.
- Very many possible tags, e.g. many millions of possible keywords and phrases as in full text search (Google). Or on the contrary - very few tags e.g. naive Bayes, which can classify resources as either "spam" or "non-spam" (naïve Bayes algorithm is examined in [44.45,10,46,47]. Authors are interested in the number of tags, which come from a controlled vocabulary; where there is some difficulty barrier to add new things, but it is possible by imposing too drastic user rights management.
- Tags, which are truly global and the same for anyone, e.g. by using a fixed taxonomy or folksonomy – short for “folk taxonomy” [21,48] vs. tags which are user specific (del.icio.us). Authors are interested in partly overlapping tag spaces, which could at some

point become mature enough to be merged between several institutions. On the other hand, institutions and even their branch offices and teams should have some autonomy w.r.t. properties and their value ranges.

- Very few properties (author, date, generic tags) as in del.icio.us or Flickr vs. very many or even unlimited number of properties - as in full-fledged Semantic Web application. The model provides large, but limited number of properties as is appropriate for e.g. a faceted browse interface.

With this model want to solve two related problems:

- How to prompt user to annotate something consistently.
- How to cover against possibility if tagging changes show signs of vandalism or inexperience.

When user has added a document, it is necessary to add some tags to document for making it able for sharing and reusing. Model uses human intelligence “sparingly” - annotators are not library science experts, are not very committed to annotate anything, but the goal is to add new knowledge items and denote them consistent.

7 Discussion

The article does not suggest any particular ontology. It investigates a networking-based approach to gradually introduce existing ontologies. They grow incrementally - property by property in a decentralized "bottom up" way. It involves building a mesh of collaborating tagging services, which evolve independently without any global coordination. The only requirement implied by the suggested architecture is ability for the services to call and to implement simple HTTP-based Web services (REST API).

The terms "representational state transfer" and "REST" were introduced of Roy T. Fielding. “[REST] is intended to evoke an image of how a well- designed Web application behaves: a network of web pages (a virtual state-machine), where the user progresses through an application by selecting links (state transitions), resulting in the next page (representing the next state of the application) being transferred to the user and rendered for their use” [44].

A RESTFul web service is a simple web service implemented using HTTP and the principles of REST. A RESTFul design may be appropriate when the web services are completely stateless. A caching infrastructure can be leveraged for performance.

If the data that the web service returns is not dynamically generated and can be cached, then the caching infrastructure that web servers and other intermediaries inherently provide can be leveraged to improve performance. However, the developer must take care because such caches are limited to the HTTP GET method for most servers.

The service producer and service consumer have a mutual understanding of the context and content being passed along. Web service delivery or aggregation into existing web sites can be enabled easily with a RESTful style.

Today REST is a key design idiom that embraces a stateless client-server architecture in which the web services are viewed as resources and can be identified by their URLs. Web service clients that want to use these resources access a particular representation by transferring application content using a small globally defined set of remote methods that describe the action to be performed on the resource. REST is an analytical description of the existing web architecture, and thus the interplay between the style and the underlying HTTP protocol appears seamless.

Hence architecture used in provided model is similar as examined in [43] “the API follows the REST style, and uses simply constructed GET URLs to fetch data, and POST requests to update or modify data”. This approach is useful whenever the possible values for the properties can be enumerated (e.g. as controlled tag vocabularies), whenever they correlate with the text of the respective document. Tagging based on SVM algorithms become less useful when classifying predominantly non-verbal content such as multimedia files or photos. SVM classifiers and tag suggestions are not very useful for properties having infinite range like arbitrary numeric values, phrase search, etc. [42, 45,46, 47]

For realising model of collaborating services there is some content management system needed. As the result of collaborating model should be created common knowledge base each user of which can find and, if it is necessary, modify materials, keeping hereto legacy of those knowledge items (version control). Authors prepare that in this case wiki technologies are most suitable[50,51,52]. So the model in general will be made as wikis - Web-based applications that provide content authoring and management functionality in a much simpler manner than its Web counterpart [53]. They simplify the hypertext generation task by offering a restricted syntax for information markup and browser-integrated editing capabilities. Links between articles are handled at the application layer, which resorts to an explicit data model of hypertext.

In contrast to the traditional Web, however, Wiki systems store linking information persistently in a database, thus providing link bi-directionality. There are a lot of wiki software used in web content management systems solutions. For realization collaborating services in model the system should provide means for creating and managing new information sources (E-learning materials). This requires means for:

- information organization – all the knowledge items needs to be structured in a meaningful way;
- collaborative authoring – E-learning materials in system should be managed collaboratively, hence multiple users need system support for putting in, tagging, searching and also editing a shared versions resource, even in parallel;
- versioning and updates – the system is required to find a way how a network of changing information resources can be managed flexibly and consistently.

The system will be used by many authors. For all of them should be able following features:

- information retrieval - in order to handle the available knowledge items the system should support search and navigation;
- personalization and context - the way information is accessed can be optimized by taking into consideration the personal profile of the users and the context of the activities currently being carried out;
- security and privacy - as multiple user groups access the same E-learning materials repository it is essential to control and monitor this procedure with the help of appropriate policies and security mechanisms.;
- integration component **-** the system needs to be useful on most of OS platforms, so as authors don't know which platform are using all the possible authors of E-learning materials – future users of system.

Estimating different Wikis authors decided to use XWiki software. Like all the Wiki softwares, XWiki is simply in use and includes a lot of features:

- User rights management (by wiki / space / page, using groups, etc...)
- PDF export
- Full-text search
- Version control
- Content and site design Export and Import
- Plugins, API, Programming etc.

On top of this, XWiki is platform independent as it was required for better integration and collaboration between different authors of knowledge items. XWiki is also an application wiki that allows the creation of object and classes. This way, forms can be developed in a very short time span and be reused to enter data on the wiki following a specific template. This means that end users can be presented with a page on which the layout is already drawn, where they can directly fill in the fields needed.

8 Conclusion

The developed ontologies in this research (as shown in figures 3 and 5) illustrate the idea how ontology bridge the gap between chaos of unstructured data (names of different models and techniques for knowledge representation) and clear knowledge of modern classification. Our approach shows that ontology development process needs some creative efforts of meta-concepts definition that helps to name the groups and structure the chaos. These ontologies may be used as an assessment procedure. Students show their knowledge and understanding while creating ontologies. Knowledge entities that represent static knowledge of the domain are stored in the hierarchical order in the knowledge repository and can be reused by other teachers. At the same time those knowledge entities can be also reused in description of the properties or arguments of methods of another knowledge entity. On the other side, educators should be aware with the ontology-based approach as a robust technique for knowledge representation. A teacher now has to work as a knowledge engineer making the skeleton of the studied discipline visible and showing the domain's conceptual structure.

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