Ontology Driven Conceptual Framework for E-Learning System

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Abstract

This research paper is based on the application and advancement of ontology in computer science, and is completely focused on ontology based conceptual framework for e-learning system. The ontology has been widely used in recent years in the field of Artificial Intelligence, computer and information science especially in domains such as, cooperative information systems, intelligent information integration, information retrieval and extraction, knowledge representation, and database management systems. The implementation of second generation of WWW, so-called Semantic Web, has made it possible to use large-scaled ontology-based applications in the field of science and research. Ontology has recently become a key technology for semantics-driven modelling. The explicit representation of the semantics of data through ontologies, enables applications to provide a qualitatively new level of services, such as verification, justification, gap analysis, etc. Ontology-based applications are subject to a continual change and we need to keep pace with its evolving standards. One of the novelties in context to ontology may be Ontology driven E-learning System. E-Learning is a process in which electronic medium has been used to access the defined set of applications and processes. With its increasing identification and recognition in academic and corporate world, a unique model or framework is required. Ontology is a specification of conceptualization; the object, process, and other entities that may be involved in making of the framework for E-learning.

Keywords: *WWW, Ontology, Artificial Intelligence, E-Learning, Semantic Web, etc.*.

1. INTRODUCTION

The word ontology is borrowed from philosophy, where an ontology is a systematic account of expansion. For computer science, what "exists" is that which can be represented. Thus, in the context of computer science, the ontology definition is "An ontology is a formal, explicit specification of a shared conceptualisation of a domain of interest". Conceptualisation is an abstract, simplified view of the world that we wish to represent for some purpose. Ontology can also be defined as "a set of representational primitives with which to model a domain of knowledge or discourse". Ontology is used in the fields like artificial intelligence, software engineering, semantic web, language

processing etc. In the field of computer science, ontology is the foundation of describing a domain of interest; it consists of collection of terms organized in a hierarchical structure that shape the reality. The following are the components of ontology: 1. concepts, terms; 2. relations between concepts, terms; 3. Properties, attributes of the concepts; and 4. Rules, axioms, predicates, constraints. Ontologies have set out to overcome the problem of implicit and hidden knowledge by making the conceptualisation of a domain explicit. Moreover, everything is liable to some conceptualisation, explicitly or implicitly. Ontologies serve as a means for establishing a conceptually concise basis for communicating knowledge for many purposes.

Learning is a critical support mechanism for organizations to enhance the skills of their employees and at the same time useful for educational institutions. Therefore, learning process need to be more efficient. The new ways of learning are some of the next challenges for every industry."The aim of e-Learning is to replace old-fashioned learning process with efficient and on-demand process of learning, relevant to the user desires. Ontology for the e-Learning processes can be set up in various ways, but ontology will include a dictionary with explanation of the terms, and indications how the terms are related to another. This approach will give a valid tool for the learning process. The role of ontology in e-learning is often underestimated; they can be useful for e- Learning systems. To deal with it, theoretical foundations for a systematic approach with application of ontology may be developed.

2. AN OVERVIEW OF ONTOLOGY

In the context of computer and information sciences, an ontology defines a set of representational primitives with which to model a domain of knowledge or discourse. The representational primitives are typically classes (or sets), attributes (or properties), and relationships (or relations among class members). The definitions of the representational primitives include information about their meaning and constraints on their logically consistent

application. Ontologies are typically specified in languages that allow abstraction away from data structures and implementation strategies; in practice, the languages of ontologies are closer in expressive power to first-order logic than languages used to model databases. Ontologies are used for integrating heterogeneous databases, enabling interoperability among disparate systems, and specifying interfaces to independent, knowledge-based services.

Ontologies can be classified in various ways using criteria such as the degree of abstraction and field of application. Based on abstraction ontology may be of following types: a) *Upper Ontology*: concepts supporting development of an ontology. It usually employs a core glossary that contains the terms and associated object descriptions as they are used in various relevant domain sets; b) *Domain Ontology:* Which represents the particular meanings of terms applied to that domain. For example the word *card* has many different meanings. Ontology about the domain of poker would model the "playing card" meaning of the word, while an ontology about the domain of computer hardware would model the "punched card" meaning; c) *Interface Ontology*: concepts relevant to the juncture of two disciplines; d) *Process Ontology*: inputs, outputs, constraints, sequencing information, involved in business or engineering processes.

3. ONTOLOGY LANGUAGES

Ontology languages are formal languages used to construct ontologies. They allow the encoding of knowledge about specific domains and often include reasoning rules that support the processing of that knowledge. Ontology languages are usually declarative languages, are almost always generalizations of frame languages, and are commonly based on either first-order logic or on description logic. There have been a number of languages for ontologies both proprietary and standards-based. Based on their formal semantics they can be split into four groups of languages:

Description Logic based Ontology Languages: Description logic provides an extension of frame languages, without going so far as to take the leap to first-order logic and support for arbitrary predicates. It has been developed in knowledge-representation research, and describes knowledge in terms of concepts (comparable to classes, or frames) and roles (comparable to slots in frame systems). An important aspect of these languages is that they have very well understood theoretical properties. These may be of three types.

- KL-ONE

- RACER

- OWL

Frame-based Ontology Languages: Many frame-based systems and languages with many additional refinements of these modelling primitives have been developed . A frame provides a context for modelling a class, which is generally defined as a subclass of one or more other classes, with slot-value pairs being used to specify additional constraints on instances of the new class. Moreover, adapted to the object-oriented paradigm they have been very successfully applied in the software engineering. Three languages are completely or partially frame-based languages.

- F-Logic

- OKBC

- KM

Hybrid Ontology Language: Gellish is an example of a combined ontology language. It distinguishes between the semantic differences among others. It also contains constructs to express queries and communicative intent.

Other Languages: A great range of languages have also been used for implementing ontologies during the last decade: *Ontolingua, LOOM, OCML, FLogic, CARIN, OKBC, Telos, Cycl.* Many of these languages had been already used for representing knowledge inside knowledge-based applications; other ones were adapted from existing knowledge representation languages. Recently, Web-based ontology specification languages have been developed in the context of the World Wide Web: *RDF, RDF Schema, SHOE, XOL, OML, OIL, DAML+OIL and OWL.* Their syntax is based on *XML*, which has been widely adopted as a 'standard' language for exchanging information on the web.

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, etc.*

4. ONTOLOGY RELATION TO SEMANTIC WEB

The term Semantic Web was coined by Tim Berners-Lee, according to Berners-Lee, the Semantic Web is "A web of data that can be processed directly and indirectly by machines". The Semantic Web is the extension of the World Wide Web that enables people to share content beyond the boundaries of applications and websites. It is a network that takes the apparently infinite amount of data on the World Wide Web, and also connects this information with

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data in relational databases. It extends the network of hyperlinked human-readable web pages by inserting machine-readable metadata about pages and how they are related to each other, enabling automated agents to access the Web more intelligently and perform tasks on behalf of users. Tim Berners-Lee developed the WWW, defined it as distributed heterogeneous collaborative multimedia information system. WWW is primarily document for centric communication services which focuses on the need of users using browsers. The Semantic Web is the next generation of the WWW, which is based on using ontologies for enhancing content with formal semantics. Expressing meaning of resources that can be found on the web is the main task of the Semantic Web.

The basic layers of semantic web are; the XML layer, which represents the structure of data; the RDF layer, which represents the meaning of data; the Ontology layer, which represents the formal common agreement about meaning of data; the Logic layer, which enables intelligent reasoning with meaningful data. Burners Lee's Semantic Web Architecture is given as follows:
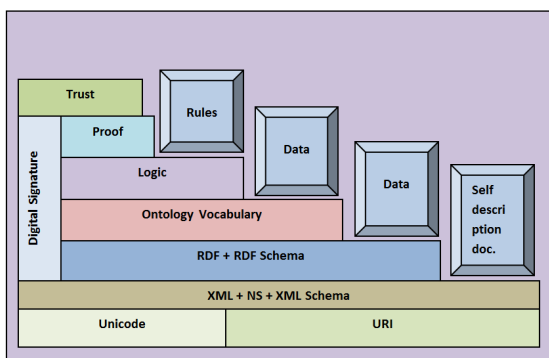

Fig.1. Berners Lee's Semantic Web Architecture

5. INTRODUCTION TO E-LEARNING

The integration of Information and Communication Technology (ICT) has opened means for the evolution of new applications and developments in the field of education. E-learning is an inclusive term that describes educational technology that electronically or technologically supports learning and teaching. Developments in internet and multimedia technologies are the basic enabler of e-learning, with consulting, content, technologies, services and support being identified as the five key sectors of the e-learning industry. The aim of E-Learning is to replace old-fashioned learning process with efficient and on-demand process of learning, relevant to the user desires. E-Learning has its origins in computer-based training, which was an attempt to automate education, replace a paid instructor, and develop self-paced

learning. The World Wide Web (WWW) is a powerful tool for research and education, but its utility is hindered by the failure of the user to navigate easily the reputable sources for the information required. The semantic web is a vision to solve this problem. The Semantic Web is a collection of standards, data structures, and software that make the online experience more detailed, intelligent, and in some cases, more intense. The Semantic Web offers learners the possibility of having a wealth of related content delivered to their desktop without explicitly identifying or requesting it. The beauty of E-learning is that new software allows the creation of very effective learning environments that can engulf everybody in the material.

6. STAGES OF E-LEARNING

In this age of Web 2.0 where content is user generated and the emphasis is on software components being modular, a learner learns the instructional contents through the electronic technology and electronic base training is known as E-learning. E-learning has a wide range of learning strategies and technologies; from CD-ROMS, videoconferencing, TV lectures, and virtual educational work, corporate universities and many more. E-learning has the potential of higher quality of education, more competitive workforce, increases the level of literacy and also is beneficial to reduce the costs of education training in institutions. E-learning has different benefits over traditional classroom study: it is much faster, less expensive, create more interest in study, get required information any time any place, keeps update easily, easy to manage large groups of students. There are four stages of E-learning, from the very basic to advance level. These stages are:

Knowledge Database: It is most basic level of E-learning, probably seen in software sites offering indexed explanation and guidance for software questions, gives the step by step instructions to perform specific task.

Online Support: Online support is the second level of E-learning. Function of online support is almost similar to knowledge database. It comes in the form of online bulletin boards, chat rooms, email, or live instant-messaging supports. Mostly targeted questions are asked in it which has the more immediate answers.

Asynchronous Training: Third level of E-learning is asynchronous training. Self learning is essential in this level; either it is CD ROM based, network based, internet based or intranet based. It is known as most traditional way of E-learning and may be totally based on self study with links to reference materials in place of live instructor.

Synchronous Training: Most advance level of E-learning, live instructor is available for everyone to negotiate their problems in a predefine time. Everyone can communicate with each other. This type of training takes place through internet web sites, audio or video conferences, internet telephone.
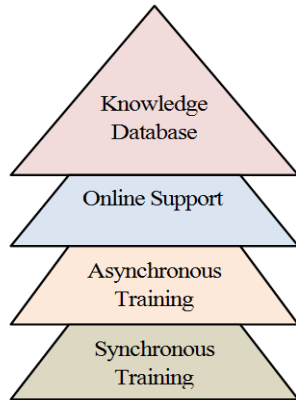

Fig.2. Stages of E-learning

E-learning 2.0 is a type of computer-supported collaborative learning (CSCL) system that developed with the emergence of Web 2.0. From an e-learning 2.0 perspective, conventional e-learning systems were based on instructional packets, which were delivered to students using assignments. Assignments were evaluated by the teacher. In contrast, the new e-learning places increased emphasis on social learning and use of social software such as blogs, wikis, podcasts and virtual worlds. This phenomenon has also been referred to as Long Tail Learning. E-learning 2.0, in contrast to e-learning systems not based on CSCL, assumes that knowledge is socially constructed. Learning takes place through conversations about content and grounded interaction about problems and actions. Advocates of social learning claim that one of the best ways to learn something is to teach it to others

7. ONTOLOGY APPLICATIONS IN E-LEARNING

Ontology is the study of a variety of entities and tries to find out that what kind of units and things are in the world. Ontology for e-learning processes can be created in many ways and ontology has a glossary with explanations of conditions, and information about how words are related to each other. This strategy will provide a valuable mechanism for learning while ontology represents conceptual descriptions of content that will identify the factors and interaction in a particular field of knowledge. The intensity of description of ontology is a hierarchical taxonomy related to the conditions and restricted or defined vocabulary with the help of semantic networks.

Ontology allow for a representation of knowledge that enables inference to be performed obtaining thus new insight. Representing knowledge in the form of a conceptualization is crucial for the automatic processing of the information on the web. Ontology can enhance the management, distribution and retrieval of the learning material within the learning management system and can thus play a relevant role in the field of E-learning.

8. METHODOLOGY FOR DEVELOPING ONTOLOGIES FOR LEARNING SYSTEM

Learning-independent applications, problem-solving methods, and software agents can use learning ontologies and knowledge bases (built from these ontologies) as data. Learning ontologies are developed with the aid of ontology development languages and tools. The proposed methodology for developing learning ontology includes six steps:

- *Identify the purpose to develop the ontology*
- *Ontology capture mechanism*
- *Coding the ontology*
- *Refinement*
- *Testing*
- *Maintenance*

9. STRUCTURAL DESIGN FOR ONTOLOGY DRIVEN E-LEARNING SYSTEM

A standard metadata is being required to develop a structure for reusable e-learning processes. The common understanding between different metadata vocabularies is not good which leads it to the use of ontology as a conceptualization of E-learning structure. The essential components of the e-Learning system are given in the following figure:
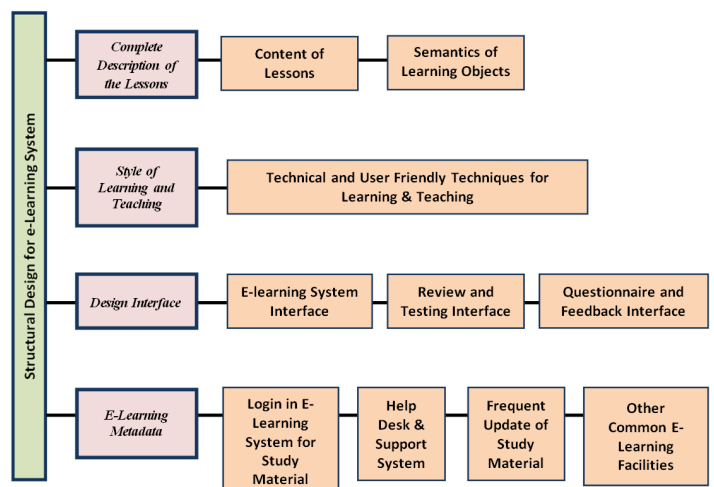

Fig.3. Structural Design for E-learning System

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Complete Description of the Lessons: The explanation of the lessons presents the structure of each chapter in more specific way. Description of the lessons display and meet all the objectives of the E-learning course. With the aspect of semantics, appropriate language must be used for example syntax and presentation of the contents must be considered.

Style of Learning and Teaching: A proper method has to be designed for teaching and learning system. Present the material in such a way that learners may have a good interaction with their instructor. Different user requirements must be met on their own. Students must be able to control the level of the process and its lessons. Another motive is means of feedback that students can give at each step in the learning process. Students get help to solve problem at any stage of the E-learning process.

Design Interface: User interface for e-learning system must be attractive and also content must be placed in the appropriate place for the students. Which encourage the students to participate in learning activities with more attention. Texts are listed in both English and in Hindi. All links on website must work, no dead links are tolerable. A good font with the right size, pleasant colours and buttons, graphics, photographs are important for students to continue with its content.

E-Learning Metadata: Metadata for E-Learning System defines the handling process of management system for E-learning. The main aspects of the system are access of the system, academic record, educational materials, learning assessment, communication between teachers and students; news updates and some other facilities such as help system for teachers and students if they face any kind of problem. Here ontology has been implemented on learning objects and management system. It creates a rich description of each object as well as to serve the Semantic Web.

10. CONCEPTUAL FRAMEWORK FOR E-LEARNING SYSTEM

The Ontology driven conceptual framework for E-learning System has been developed using web services, an ontology and agent components. It is shown in Fig.4. The main challenges of E-learning systems are efficiency and relevancy of the results. The most important part of the ontology driven E-learning system is an architecture overview of the approach that focuses on the following:

- The definition of abstract services
- Web services instances
- Learning object metadata (LOM)
- eXtensible Mark-up language (XML)
- Resource Description Framework (RDF)

- Web Ontology language (OWL) and the users expected goals

While developing protocols within such architecture, that promotes interoperability, there is a chance that these protocols will not always be understood. The aim of the framework is to provide an integration service platform that offers learner-centric support for web-based learning, which will improve the efficiency of the E-learning applications and as well the relevancy of the search results. The E-learning system using learner or instructor system, designed as a web-based data transmission system. In E-learning system, a learner has to perform different functions when he tries to access the system. First of all a learner need to log in the system if he is already a member of the system otherwise he need to register in the system to fill the information about him so that he can access the system next time. Then the learner has to select the subject and chapter of that subject. Take the quiz and get marks on it. Finally the learner needs to log out the system if he wants to exit the system. The instructor side uploads the information such as to add the new subjects, chapters, quizzes and exams. Administrator side keep the student record in his database and also can edit the data if required.
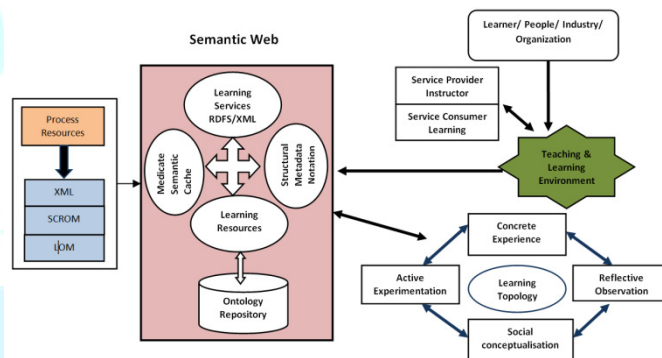

Fig.4. Conceptual Framework for E-learning System.

11. ONTOLOGY USED IN DEFINING METADATA FOR E-LEARNING

When ontology for any metadata is structured it is already understood whether it will be a Lecture, Example and so on and it hardly fits to another function. E-learning system has different data aspects. The most general aspect is Educational Material. Educational Material has two subtypes:

➢ *Course Material:* It can be further specialized into Lecture, Example, Lecture Note, Course, Exercise, and Project Assignment, etc.

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> *Examination Material:* It can be further specialized to Project Task, Exam Task, and Exam, etc..

Course Material Metadata represent different context of a data. It means that learner can distinguish at least between examination and study material. The important concept of the ontology is the "Relation". With it, learning Object can be connected with other in terms of versioning, belonging, requirements and other useful relationships. Ontology gives vocabulary to describe the conditions of a substance, as well as logical statements that describe what the case is, how the components and context may or may not be classified and related with each other. The system contributes to development, learning and assessment of skills of the students. The system can be a good ontology driven E-learning system with a structured learning environment that is transparent and accessible via the Web. This system allows reusing of materials and use of Semantic Web functions for the configuration and composition.

12. ONTOLOGY FOR E- LEARNING MATERIAL SEARCH

The E-Learning domains, the traditional methods of development, of course apply the testing strategies and should be considered in the development of e-learning environment. The contents can be quite interesting to discuss the implementation of the proposed criteria for the Web-testing of systems for the analysis and testing of content. The ontology of a service called Learning Material Search is specified using ontology web language (OWL). The service takes inputs from Course, Examination and Education material. The Education material has two subclasses including Course and Examination. The Education material has a property which can have only three values: For Student, For Teacher and For Management. Education material has the following constraints:

- Course material are those with Lectures notes and study materials, i.e., Course material (Educational material has ∩ Relation (Course material)).
- Material for Education is those with student or management i.e., Material for Education ≡ (Education ∩ has Material (Student ∪ Management)).
- Examination material is those with Exam Task and Exam i.e., Campground (Education material ∩ has relation (Examination material)).

Web Ontology Language is a specification for the representation of knowledge in e-Learning System, adds features of networked logic for e-learning material search.

Ontology as a basis for the assessment of knowledge evaluation emphasizes the dynamic potential evidence in the testing process for students.

13. CONCLUSION

Ontologies are becoming popular largely because of what they promise: a shared and common understanding that reaches across people and application systems. Undoubtedly, there is no single methodology for developing an e-learning ontology. Ontology design is a creative process and no two learning ontologies, designed by different people, would be the same. Learning ontology design choices are affected by the potential applications of the ontology and the designer's understanding and view of the domain. Learning systems are facing rapid changes with the advent of semantic web technologies, and intelligent learning applications become possible with the development of ontologies. There is now a need for developing an infrastructure to manage the learning information and deliver to e-learners what they want. Semantic web and ontology-based intelligent learning information systems is one of the solutions. By joining these major strategies for knowledge representation, domain knowledge in e-learning provide fairly good expressive power and computational costs.

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