Ontology Based Approach for E-Learning in Concurrent Enterprising

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Abstract
The paper proposes an ontology-based approach to implement E-Learning within a Collaborative Enterprise environment having a large base of applicability for engineering sciences. The approach is based on a new holistic model - the E-Learning Cube – conceived as tool for better understanding and characterization of the basic principles and mechanisms of E-Learning, for efficient use of the underlying infrastructure. The main components of a formal ontology are covered: conceptualization in the form of an abstract model, explicit definition through a vocabulary, formalization using the XML language and sharing ability in terms of capturing consensual knowledge.

Keywords
Ontology, E-Learning, Virtual Enterprise, Collaborative Environment

1 Introduction
The convergence of learning and technology enable individuals and teams to bring value for their customers and competitive advantage for the team or organization they belong. The role of E-learning is on one side to provide the tools needed to create, deliver and facilitate the training of the knowledge workers, anytime and anywhere; on the other side to enable the build out of enduring communities of practice where individuals can come together to share knowledge and insight, long time after the training program has occurred. However, no communication is possible - not to mention collaboration or co-operation without a single understanding or at least compatible meaning of the terms exchanged between the different participants. In fact, communication cannot be reduced to only exchanging data but must take into account the exchange of knowledge. Co-workers in an enterprise work at their own levels, using their own knowledge and engineering models. Furthermore, the software tools extensively used in engineering sciences require specific and dedicated representations, are more concurrent than collaborative. The way to address this problem is to define a shared understanding. Agreement must be achieved about the shared knowledge used as a communication medium among people and software tools. If communication is the first cornerstone to collaborative product development, knowledge sharing between actors is the second one [Roche, 2000]. That is the compelling reason for proposing ontology as a set of definitions of formal vocabulary in a way that is consistent with respect to the theory specified by ontology. Based on current definition [Gruber, 1993] of ontology as a formal, explicit specification of shared conceptualization the present paper proposes ontology for e-Learning.
2 Ontology as a Specification Mechanism

Although the team ontology is just now getting widespread acceptance due to the “semantic pressure” put on Web – based communication, all of us have encountered ontologies in various form. The next generation of sustainable, dynamic and agile enterprises (virtual enterprise, concurrent enterprising, collaborative enterprises, and collaborative networks of enterprises) should use the web based ontologies for their daily activities. Often terms used in paper systems have been sensed in computer based systems. According to some authors [Wiederhold, G. 2005] a hierarchy of ontologies could include:

- lexicon: collection of terms in Information Systems;
- taxonomy: characterization of classification of terms;
- database schemas: attributes, ranges, constraints;
- data dictionary: guide to systems with multiple files & owners;
- object libraries: grouped attributes, inherence, methods;
- symbol tables: terms bound to implemented programs;
- domain models: interchange terms in XML, DTS, schemas.

The small, focused ontology is more appropriate for the domain of concurrent engineering and enterprising in comparison with a large, world wide one, which could cause the problem of semantic inconsistency.

The small, focused ontology is addressing group of individuals that cooperate with some shared objectives on a regular bases. On the other hand, the databases within collaborative companies or interest group within collaborative companies or interest group within Professional Virtual Community [Camarinha 2005].

Taking into account that the first objective which has been achieved successfully within the IST – Framework 4 – project “Concurrent Enterprising Network of Excellence” (www.cenet.org) has concerned with creating a taxonomy, as the simplest ontology for the domain of concurrent engineering [M. Pallot, 1996] [K. Pawar, 2000], one could evaluate the achievement of seven years, long period of seamless research for higher education and training for the specific multi-disciplinary domain of concurrent enterprising which has being developed at the Human Resources Training Centre within University POLITEHNICA of Bucharest – Romania [Stanescu ICE’01, Bremen].

As mentioned in the previous section, two entities can communicate only if they agree upon on the meaning of the terms they use. Ontology, understood as an agreed vocabulary of common terms and meanings within a group of people, is a solution to that problem. However it should be mentioned that while the main goal of ontology is to normalize, or at least to try to reach an agreement on the meaning of terms, the term “ontology” itself is not clearly defined and seems to generate a lot of controversy. For example, Gruber’s statement [Gruber, 2001]: “an ontology is a specification of a conceptualization”, is given different interpretations by Guarino [Guarino, 1995]: conceptualization, formal ontology, ontological commitment, ontological engineering or ontological theory. The present paper considers ontology as a collection of agreements upon a vocabulary of common terms and meanings in some domain, particularly e-Learning. Uschold [Uschold, 1996] identifies three main categories of uses for ontology in concurrent engineering, including enterprise modeling and multi-agent systems that are extendable also to engineering sciences:
1. Communication between people and organizations by providing a shared understanding;
2. Inter-operability between systems where ontology is used as interchange lingua;
3. Systems engineering by supporting the design and development of software systems: specification, reusability and reliability.

It is also worth to mention that concurrent engineering also relies on corporate ontology that are a means to preserve corporate knowledge in order to better diffuse and reuse it.

Gruber’s definition of ontology [Gruber, 1993] as formal, explicit specification of shared conceptualization is taken as basis for development. For the purpose of this paper „conceptualization” refers to the abstract model of the e-Learning Cube to be presented in the next section. „ Explicit” means that the type of concepts used and the constraints on their use are explicitly defined using a vocabulary of several hundred specific topics that was not included in the present paper due to space constraints. „Formal” refers to the fact that the ontology should be machine understandable. In this respect the e-Learning cube was decomposed in a Direct Acyclic Graph (DAG) structure that made possible its formal description with XML (Extended Markup Language). The term „Shared” reflects the trend of ontology as being able to capture consensual knowledge. Efforts are going both in the scientific direction as well as towards real world implementations of e-Learning solutions. In this respect case study were included.

The XML is a standard way of structuring text with self-defined tags, while the Resource Description Framework (RDF) and RDF-Schema (RDF-S) is based on XML and allows specifying semantic metadata in a document, e.g. in a HTML document.

The RDF is a mechanism to give meaning to data by telling something about it (Ding et al. 2002). The RDF data model consists of statement about resources by using “object-attribute-value” triples.

Our research is in progress, such as the first phase is concerning with XML-based description of E-learning cube. Some achievements regarding the RDF-based approach for ontology in CE is going to be presented during the ICE Conference.

3 The Abstract Model: E-Learning Cube

There is much controversy around the E-learning topic today. Be it from material reasons (infrastructure) or immaterial (lack of strategy, poor content, lack of interactivity and pedagogical skills, etc.), e-Learning did not succeed everywhere. That is the reason why the present paper introduces a new model, the e-Learning Cube, as a tool able to facilitate the understanding and faster identification of the root causes for various problems and ensure a successful implementation process (Figure 1). The available literature provides various uni-dimensional models that capture part of the problem, referring infrastructure or services issues [Dumke, 2003] or dealing with the content involved during the knowledge transfer [IBM, 2001]. It became obvious that a multidimensional approach may represent better the complexity of the domain and this is in fact how the E-Learning cube was evolved from the extended CIM-OSA, eCube’ [Stanescu, 2002] with three orthogonal dimensions (Infrastructure, Content and eServices) and their related components as listed below:

- Infrastructure dimension with the following components:
  - TCP/IP
  - Content Delivery Networks
- Learning Management System
- Learning Portal
  - Content dimension with the following components:
  - Multimedia streams
  - Reusable Information Objects
  - Reusable Learning Objects
  - Learning Curriculum
- E-services dimension with the following components:
  - Knowledge Management
  - Authoring
  - On-line Training
  - E-Business.

![The E-Learning Cube Model](image)

Figure 1: The E-Learning Cube Model

The generic modeling framework, depicted in Figure 1, has been presented in detail within the Ph. D. thesis [Garlasu, 2005]. During last six months a new research project which is aiming at identifying the main components of the E-learning systems (Learning Contend Management Systems or Virtual School [Horton, W & Horton K. “E-learning tools and technologies” Published by John Wiley, 2003, Library of Congress Cataloging – in Publication data 0-471-44458-8]) is in progress.

The system includes: resources (technology, human resources and financial ones) curriculum, courses, lesson, pages, and all media over IP description and particular RDF framework.

4 Formal Representation Using XML

It is possible to organize ontology into layers [Angele, Studer, 2003], where each layer expresses a meta-level view on another layer. Starting from this assertion it is possible to decompose the e-Learning cube into a DAG structure (Direct Acyclic Graph) as in Figure 2. Thus a task specific ontology (e-Services), may be defined on top of a domain ontology (e.g. Knowledge Management), and a PSM (Problem Solving Method) specific ontology, (E-Learning) e.g. for heuristic classification, may in turn specified on top of the task specific one. A Tree like representation relies on a precise definition of the terms. The meaning of a term is the conceptual knowledge to which it refers. This means that the signification of a term that refers to a concept
is the definition of this concept when the meaning of a set is the logical property that defines the set [Rohe, 2000].

Figure 2: DAG Representation of the E-Learning Cube

The definition of terms and of meanings, as well as their exploitation, may use of an adequate language having Lisp like syntax as in KIF (Knowledge Interchange Format) [Genesereth, 1992] whose instructions are structured in two sets. The former contains all the necessary instructions for definition and modification of `term-meaning' couples that constitute the ontology. The second set of instructions is used in order to exploit the defined ontology, mainly for queries. Viezzer [Viezzer, 2004] proposes a modern, Web oriented approach that is available through OIL (Ontology Inference Layer).

The next step in defining the ontology is description using a formal language. In this respect XML was selected for several reasons:

1. XML describes data objects called XML documents. This feature is essential for the purpose of ontology as an explicit specification of a conceptualization: the objects, concepts, and other entities that are assumed to exist in some area of interest and the relationships that hold among them.

2. XML is a markup language for structuring data rather than formatting information (such as HTML).

3. The structure is tree like – nodes of an XML document modeled as tree of nodes – may be operated by XPATH (XML Path Language).

4. The Document Object Model (DOM) defines programming interfaces for accessing and changing an XML document as a tree structure. DOM API is platform and language independent and stores an entire document tree in memory. It can dynamically access and update the content, structure and style of documents.

5. A document is composed of Entities, each entity can contain one or more logical Elements, and elements can have Attributes. When the knowledge of a domain is represented in a declarative formalism, the set of objects that can be represented is called the universe of discourse. This set of objects, and the describable relationships among them, are reflected in the representational vocabulary with which a knowledge-based program represents knowledge. Thus, the ontology of a program can be defined as a set of representational terms. In such ontology, definitions associate the names of entities in the universe of discourse (e.g., classes, relations, functions, or other objects) with human-readable text describing what the names mean, and formal axioms that constrain the interpretation and well-formed use of these terms.
6. A well-formed XML document can be validated by rules enforced via DTD (Document Type Definition) or XMLS (XML Schema). This feature is extremely useful for the validation of logical elements. Since an ontological commitment is an agreement to use a vocabulary (i.e., ask queries and make assertions) in a way that is consistent (but not complete) with respect to the theory specified by ontology, the DTD or XMLS can be used to load the vocabulary based on a grammar or some kind of framework.

7. Extensible Style Sheet Language (XSL) adds the capability of transforming an XML document into a HTML document with formatting tags for Web display purposes. This makes the ontology available for consultation through Internet via queries and assertions exchanged among agents. Ontological commitments are agreements to use the shared vocabulary in a coherent and consistent manner.

The program in Figure 3 presents the XML implementation of the e-Learning cube model unfolded as a DAG of Figure 2. The program has a root node named “E-Learning” with three elements (the Infrastructure, Content and eServices dimensions). Each dimension is identified by a dimension_id followed by its 4 components, also described as elements.

5 Case study of e-learning focused on Concurrent Enterprising domain

The new focused e-learning cube is under tests in the Human Resources Training Centre according to the project management of a Romanian National grant for M. Sc. in Concurrent Enterprising complaint with Bologna – Bergen requirements.

The root of the present paper has been done successfully in 1998 by Peter Antoniac (“Concurrent Engineering Taxonomy Database Development and Maintenance”) supervised by Aurelian Stanescu.

To illustrate our approach for designing e-learning system within Concurrent Enterprising domain, we chose the following lesson: “Constraints on manufacturing process”. (Fig 4.a)
6 Conclusions

Senge [Senge, 1990] defines the learning organizations as entities that continuously expand their capacity to create their future. In the knowledge economy one approach is to create an environment and a culture that encourages knowledge generation and sharing, supports learning by doing and ensures that learning is incorporated into future activities, decisions and initiatives of the company. Hodgins [Hodgins, 2000] proposes the learnitivity model of a continuous spiral for conversion of tacit knowledge (such as know-how and experience) into explicit knowledge that can be captured and turned into new tacit knowledge gained from learning by doing. In this context and in the knowledge based economy, learning can be seen as an integral part of knowledge creation spiral that involves: performing, capturing, managing and learning. The Internet and the Web are the tools that make possible the process above and it is essential in the work of learning. Moving into the future, we look at virtual reality, mobility and eventually K-business – a business that markets and sells knowledge over the Internet.

The present paper advanced ideas for creation of an e-Learning ontology. This approach was based on an original model of the e-Learning cube and its decomposition in a Direct Acyclic Graph. An implementation using the XML language was proposed.
The cube model was used for correct positioning of an e-Learning system in a collaborative environment mostly when it came to roles of various entities, strategy and rollout planning. A case study was presented in [Garlasu, 2005]. Another example of utilization of the Ontology is the Virtual meeting robot introduced as a first attempt to develop the new cost effective „intelligent” device supporting the structured approach in e-Learning [Dumitrache, 2005].

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