Roadmap for Reaching Semantic E-Learning – Test Cases

Johannes Lischka, David Mooslechner, Nicole Murtinger, Martin Reingruber

University of Vienna, Institute for Business Informatics and Computer Science, Department of Knowledge Engineering

Key words: E-Learning, Semantic Web, Test Cases

Abstract:

This paper envisions a roadmap to future E-Learning within a Knowledge Society with the help of an E-Learning Framework: coming from proprietary LMS, XML based standards extend E-Learning towards course-sharing finally reaching real life-long learning where time and space are not an obstacle anymore. The Framework consists of four dimensions and clearly points out differences between types of learning: kind of methodology, learning management, treatment of knowledge, didactical concepts, student- or teacher-centric learning, succession of learning objects and technological issues like standards.

Current efforts and courses in E-Learning as one instance of the E-Learning Framework (document-centric) are reduced to using proprietary Learning Management Systems (LMS). Fortunately, most of the leading LMS already implement standard interfaces for importing courses (IMS Content Package, etc.). Unfortunately, these standard interfaces are only able to transfer data or documents and still lack information about meaning (e.g. is there more on a certain topic, who wrote the article and how can I contact and maybe meet this person …). The latter scenario Web as another instance of the E-Learning Framework (resource-driven) pretty much reflects the vision of the Semantic but can also be applied to E-Learning: current didactical approaches restrict E-Learning to hierarchical and document-centric scenarios reflecting the XML paradigm but Semantic Web technologies could leverage the networked structure of technologies like RDF that could make personalized and resource-based scenarios possible.

Trying to show the feasibility of resource-driven E-Learning, the roadmap sketches several test cases to show scenarios and prototypical implementations of how to pack more meaning into E-Learning.

1 Introduction and Motivation

Current efforts and courses in E-Learning (document-centric) are reduced to using proprietary Learning Management Systems (LMS). Fortunately, most of the leading LMS already implement standard interfaces for importing courses (IMS Content Package, etc.). Unfortunately, these standard interfaces are only able to transfer data or documents and still lack information about meaning (e.g. is there more on a certain topic, who wrote the article and how can I contact and maybe meet this person …).

The latter scenario Web as another instance of the E-Learning Framework (resource-driven) pretty much reflects the vision of the Semantic but can also be applied to E-Learning: current didactical approaches restrict E-Learning to hierarchical and document-centric scenarios reflecting the XML paradigm but Semantic Web technologies could leverage the networked structure of technologies like RDF that could make personalized and resource-based scenarios possible.
Trying to show the feasibility of resource-driven E-Learning, the roadmap sketches several test cases to show scenarios and prototypical implementations of how to pack more meaning into E-Learning.

In the following, chapter “E-Learning Framework” introduces a modeled approach to describe E-Learning scenarios. With the help of this framework, the roadmap is defined. Chapter “Test-Cases” sketch prototypical implementations in the context of Semantic E-Learning. Finally, chapter “Outlook and the Future of E-Learning” sketches a vision of life-long learning.

2 The E-Learning Framework

In order to be able to categorize E-Learning scenarios, common grounds for comparison has to be found, i.e. a theoretical framework has to be introduced. This framework has to provide the “common-language” or ontology to interpret between business and learning requirements and technical implementation. Compared to Business Engineering (Zachmann Framework [1], ARIS Framework [2] and House of Business Engineering [3], E-BPMS [4], GERAM [5], CIMOSA [6], etc.) or Architecture, where detailed plans of buildings together with additional information concerning electrical installations are understood by a variety of people and roles, E-Learning lacks this common way of understanding. The proposed E-Learning Framework is a first step towards a structured ability to describe E-Learning applications.

This paper suggests, that E-Learning is currently undergoing a paradigm shift on a technological dimension from document-centric XML solutions (e.g. exchanging questions and tests with the help of IMS QTI specification) to resource-driven Semantic Web approaches (everything in the web can be used for learning). In this context, three-test-beds are presented.

The E-Learning Framework depicted in Figure 1 consists of the following four dimensions:

- Management
- Content
- Didactics
- Technology

Of course, the E-Learning Framework is too generic and eventually has to provide each dimension which is symbolized by the process icon within each quadrant of Figure 1.

The general roadmap of learning can be summarized probably with 3 steps until finally the full potential of the E-Learning Framework is exploited that enables life-long learning in a Knowledge Society:

1. Traditional on-campus (classroom) learning
2. Blended Learning (document-centric)
3. E-Learning embracing the Semantic Web (resource-driven), focused on in this paper
4. Future: Life-long learning

Current approaches very much focus on the Technology-dimension with the help of technology driven and document-centric technologies based on XML applications. The exchanged documents can be transferred from one LMS to another and get encapsulated into the proprietary solution. Exactly this drawback is the motivation for the test-beds in this paper described later.
But technology is only the lever to reach organizational – or in the case of learning – didactical or pedagogical goals. The Didactics-dimension is coping with problems in this area. The Content-dimension per se is a prerequisite in learning scenarios. Content has to be aligned around didactical frameworks and technical implementations.

Finally, the Management-dimension guarantees that E-Learning process flows can be incorporated into a broader business scope providing measures and evaluation methods so that E-Learning can be included into a kind of value chain.

Around the E-Learning Framework, national and international guidelines or laws have to be respected; that is why several layers are systematically embracing it.

The Test-Cases presented in this paper reflect the technological development (focus on the Technology dimension; the other three dimensions are not covered) as proposed by the authors of this paper: current E-Learning focuses on document exchange with the help of specifications produced by the IMS Global consortium [7] and others.

But the paradigm shift from classroom-centered learning to student-centered life-long learning cannot be addressed with documents that reside in proprietary LMS. Therefore the authors show a roadmap to web-based and resource-centric technologies coming from the Semantic Web. The solutions used in the Technology dimension depicted in the E-Learning Framework therefore also have to reflect this paradigm shift. The added value of Semantic Web Technologies for E-Learning embraces the distributed and platform-independent character of the Semantic Web, i.e. reasonable mobile E-Learning applications. Concrete advantages are discussed within the respective section.

The three Test-Cases are

1. General transformation of XML based E-Learning scenarios to an RDF-based data pool
2. Protégé Ontology Platform to create organizational models of university scenarios based on OWL reasoning
3. Mozilla Platform with RDF data exchange linking teachers, students, course relevant documents and curricula
4. Introducing the Open Knowledge Initiative

The following chapter is dedicated to these three Test-Cases.

3 Test-Cases

The Test-Cases described in this Chapter make up tiny bits on the road to E-Learning applications based on Semantic Web Technologies according to the presented E-Learning Framework.

3.1 Test-Case 1: RDF Learning Objects

Today knowledge is a very important factor. Companies and people need it as a part of their business. Efficient research is the basis to working with knowledge. In order to manage knowledge, Semantic Web Technologies like ontologies help to annotate resources and relationships. In addition to conventional methods like Dublin Core [8] powerful description languages were required to display manipulate these ontologies.

In the context of E-Learning, the use of ontologies brings is a heavily discussed topic, because relationships between learning objects cannot be annotated with current XML standards that reflect a document-centric paradigm. This Chapter presents an approach to use resource-driven technology RDF to describe pool of learning objects.

Figure 2 therefore shows the interdependencies among different kinds of Knowledge Representation Formalisms from a historic and evolutionary point of view yielding into the technologies that were used as a basis for the presented prototype in this Chapter.

Before stepping into details about the E-Learning prototype basic ideas about Knowledge Representation Formalisms especially focusing on E-Learning are topics of the following subchapters.

![Figure 2: Relationships between Knowledge Representation Formalisms](image-url)
3.1.1 Knowledge Representations: Ontologies

IT-driven Knowledge Representation Formalisms traditionally emerged around the Artificial Intelligence community. Exemplary, rules [8] are an exponent of dynamic representations and logic [10] – represented by PROLOG (programming logic) and Description Logics – are an exponent of static representations.

Starting from this net based structure that emerged in the 1960ies under the name of Semantic Nets, the W3C proposed a Knowledge Representation Formalisms concept named Semantic Web [11]. Technologically speaking the Semantic Web concept is realized and proposed with the use of the RDF model [13]. RDF is very successful, because of its net based structure and its possibility to save data in XML-binding. RDF Schema (RDFS) [14] extends RDF with the ability of creating the vocabulary and semantic constraints.

In the past years, a lot of “extensions” to RDF were created: DAML [15] or OIL [16] are destined to take the Semantic Web to its next steps. In order to manipulate ontologies, software tools and APIs were created, in particular the Jena Semantic Web Toolkit [17]. This toolkit can create and manage DAML, RDF and OWL [18] ontologies. Furthermore it is possible to make queries with JAVA methods or with an additional query language named RDQL.

Two actual vocabularies that strongly influence the E-Learning landscape are Dublin Core (DC) and the Learning Object Metadata (LOM) [12] which both are also available in RDF mappings. DC is created to save knowledge about knowledge for general resources with its 15 elements and a lot of qualifiers. LOM contains more than 70 tags arranged in 9 categories for learning objects. Both set the basis for the prototype that is described in the following.

3.1.2 E-Learning Prototype

To show the benefit of the combination LOM, RDF and Jena, a prototype was implemented that makes use of the ontological concepts. This application is based on JAVA-Servlets and includes the Jena-classes (see Figure 3).

![Figure 3: Prototype components](image-url)
The main functions of the prototype are (see Figure 4):

1. Creating a file to hold the information of the user (name, E-Mail address, ID, etc.)
2. Providing a form to type in the information about a user
3. Providing a form to annotate the information of a resource, e.g. a book, text on the web or a learning object
4. Creating a file to save the information of the resource in RDF-LOM
5. Providing a form to find a resource and depending whether a course ID is provided the user gets additional information: did he already “graduate” from the resource or does the resource require other resources as prerequisites
6. Providing a form to find colleagues, who have graduated in a particular learning object

Figure 4: The user interface

3.1.3 Benefits of RDF and LOM

There are a lot of benefits of RDF and LOM appeared to relational databases.
- Finding particular information in a tree based structure is more efficient than searching in a relational database because the information is held in a table like structure.
- This knowledge representation can generate queries in a transitive way. (xRy and yRz implies xRz)
- Some internet browsers like Mozilla are working with RDF to describe resources.
- By saving user information with vCards every RDF database contains saved names of tags, facilitating interchange between different platforms.
- RDF is a platform independent way to save and manipulate data.

In the future some of the published knowledge representations will disappear. It is therefore important for LOM to obtain an official status to enlarge its appearance.
3.2 Test-Case 2: Creating a University Ontology with Protégé

Protégé was developed by the University of Stanford [19] and is an ontology editor with graphical user interface, which enables the easy creation of ontologies, data schemes plus allowing entering data directly. With the help of various Plug-ins, it is possible to enhance the abilities of Protégé considerably.

For this special Test-Case, Protégé was enhanced with the OWL Plug-in to create and modify OWL Ontologies. The additional Features [20] included in this Plug-in are:

- Load and save OWL and RDF Ontologies
- Edit and visualize OWL classes and their properties
- Define logical class characteristics as OWL expressions
- Include reasoners such as description logic classifiers
- Edit OWL individuals for Semantic Web markup

Additionally a Classifier Server called Racer was used to be accessed through the Protégé functions “Inconsistence Check” and “Classify Taxonomy” [21]. At the first start of the ontology editor, the program offers the user to create a new and empty OWL-File, which will be used to create an ontology containing information about the structural design of a university (note, that the vocabulary was purely by the authors and did not pass any specification processes; the main purpose of this prototype is to show added value of Semantic Web constructs for E-Learning).

Figure 5: Protégé screen shots
The main view depicted in Figure 5 (top left) of the ontology is a hierarchical class tree, which shows the already created classes and is the access point to add information to the ontology.

The class Someone is serving as a test class to show the Racer server’s classification regarding the properties in connection with the conditions included in the main tree. Every class marked orange in Figure 5 (top left) has at least one asserted condition, in contrast to the classes marked yellow. Associated with the class CourseInstructor asserted conditions are shown in Figure 5 (top right). The class owl:Thing is simply the root class.

To create a condition, it is necessary to create a property which later is required to be checked by the classification server (see Figure 5, center right): the property hasAuthorization is of the domain CourseInstructor and is pointing to the class Authorization.

After creating the necessary classes and properties, it is now possible to use them to build Asserted Conditions: there are two different Authorizations for university related persons in Figure 5 (bottom) to be assigned to a class which can then fulfill the condition of hasAuthorization.

![Figure 6: Asserted Conditions of class Someone](image)

To demonstrate the work of the inference machine of the classification server, an Authorization is assigned to the test class Someone, as shown in Figure 6 (left). The result of the classification of the taxonomy by the Racer server (which automatically contains an inconsistency check) can be seen in Figure 6 (right).

The classification server has analyzed the classes, and rearranged the hierarchy according to the rules and properties of the classes and individuals. As a result to this process, the class Someone was repositioned and classified as a CourseInstructor. It does not fulfill the conditions of the class of professors and from this it infers that it cannot be super- or subclass of the class Professor and is positioned parallel to it.

Of course this has not to be done with classes, but is also possible with instances of these classes. Providing enough instances, it is also possible to create complex queries, e.g. which individuals of the class Student have accomplished a certain number of IT courses in a certain year? Unfortunately, not all of the features OWL offers to ontology designers can yet be used in full extent at the time of creation of this paper.

### 3.3 Test-Case 3: The Mozilla Platform

The Mozilla Platform [22] not only consists of several Internet Applications like Browser, Mail Client and IRC, it also can be used to develop applications. The big advantage of Mozilla is the architecture that allows creating a graphical user interface and functionality on the one hand and using them on several platforms such as Linux, MS Windows or OS/2. Mozilla uses standards like CSS, XML, JavaScript or DTD what makes it easy to write a
program. RDF is used as data source – examples for data sources are the history or the bookmarks of the Mozilla Browser. In the same way other RDF-files can be used to create content within the application dynamically.

In an E-Learning-context, which content should be involved and how it could be linked to other data to gain learning benefits has to be defined in the first place. Obviously there is an advantage to have a one-stop-shop where a student can find his courses, the involved people, relevant documents and further information. Pre-condition for this advantage is the access to the data which has to be in a machine-readable format. As one of the most popular RDF vocabularies these days, RSS-feeds [23] are de-facto standard for publishing information in a Semantic Web context. These feeds are used to publish the latest news of a website, a web-forum or a Weblog. Other information compliant to an official standard or specification like LOM of course can be re-used in the Mozilla environment.

To develop a program in Mozilla it is important to know the exact data structure of the data sources (RDF-files). With the help of the XML-based user Interface Language (XUL) it is possible to write applications that run within the Mozilla-browser and that offer common graphical elements.

The prototype that has been realized within a course at the University of Vienna offers a news feed-reader tab (see Figure 7, top left), a tab showing personalized courses (see Figure 7, top right), a search tab using different search-engines (see Figure 7, bottom left) and a people tab searching for people and related information (see Figure 7, top right). The aim of the feed reader is to get the latest news from a website that is related to the study “Business Informatics” that offers RSS-feeds.

![Figure 7: Mozilla prototype](image-url)
The biggest challenge in the design phase was the research for remote RDF-files that could be used to gain benefit in the E-Learning context. If there will be more RDF-resources in the future, the application could offer further functionality and the information can be found closer together than it is nowadays.

4 Summary and the Future of E-Learning

This paper presented E-Learning Test-Cases paving the road to a future learning, where resources are described and networked semantically to gain more knowledge out of existing information. According to the presented E-Learning Framework, the Test Cases explore scenarios with focus on the Technology Dimension especially scrutinizing Semantic Web Technologies. The interrelation between the Test-Cases can be seen as follows:

1. Test-Case 1 showed the treatment of learning objects with the help of LOM ontologies
2. Test-Case 2 goes a step further and uses OWL as description technology for vocabularies of learning objects
3. Test-Case 3 describes an application framework to treat Semantic Web resources

In order to fully leverage the Semantic Web to reach Semantic E-Learning fully supporting the E-Learning Framework, future work focuses on:

- **Test-Case 1: RDF Learning Objects**
  - No forms to force users to annotate information manually
  - Automatic creation of annotations (Re-use of already existing information and concatenation of existing ontologies, e.g. DC, LOM with FOAF and RSS, etc.)

- **Test-Case 2: Creating a University Ontology with Protégé**
  - Show reasonable scenarios to leverage the efficiency of OWL (the course can only be taken if restrictions are respected, an instructor cannot be a student, etc.)
  - Use existing vocabularies to form a University ontology
  - Include more information for evaluation purposes to answer questions with regards to a knowledge balance

- **Test-Case 3: The Mozilla Platform**
  - Use the full potential of the framework
  - Create adapters for the use of any vocabulary
  - Include OWL reasoning
  - Define reasonable mobile applications

Besides the enhancement of the E-Learning Framework on the Technology Dimension, all other Dimensions – especially the Management Dimension – have to be treated carefully. In this context, special focus will lie on providing a generic modeling language, so that all domain requirements defined by the E-Learning Framework can be put into operative action automatically. Disappearing geographical borders and distances together with developments introduced by the European Union in the context of (E-)Bologna drive E-Learning scenarios in a direction, where IT has to be a reasonable henchman for educational institutions to work together across several countries.

References:


[9] Lunze, Jan: Künstliche Intelligenz für Ingenieure; Band1: Methodische Grundlagen und Softwaretechnologie 1994, Oldenburg


[24]

Author(s):

Johannes Lischka, Mag.; David Mooslechner; Nicole Murtinger; Martin Reingruber  
University of Vienna, Institute for Business Informatics and Computer Science, Department of Knowledge Engineering  
Brünnner Strasse 72  
A-1210 Vienna  
johannes.lischka@univie.ac.at