e-Learning, Semantic Web Services and Competency Ontologies

Darrell Woelk
Elastic Knowledge Solutions
dwoelk@elasticknowledge.com

Abstract

This paper describes a proposed system for competency-based just-in-time learning that uses competency ontologies and semantic web services to deliver learning objects to learners in a corporate environment. A competency ontology is a rich, semantic description of the competencies an employee must possess in order to participate in specific activities of the business processes of a company. Semantic web services are web services based on SOAP, WSDL and UDDI that have been further augmented with semantic descriptions. These semantic descriptions enable people and software agents to more efficiently identify services that can provide the proper learning objects. The key to the just-in-time delivery of learning objects is an explicit representation of the business processes of the enterprise and learning processes personalized to each employee.

1. Competency-Based Just-in-Time Learning

A goal of corporate e-learning is to increase efficiency by identifying precisely the training that an employee needs to do their job and provide that training in the context of day to day job activities of the employee. Figure 1 illustrates the flow of activity to implement competency-based just-in-time learning services in an enterprise environment. In the lower right hand corner is a representation of a couple of the business processes of the enterprise. The example shown here is the interaction between an ERP process implemented using SAP and a CRM process implemented using Siebel. In the upper left hand corner are the ontologies that capture knowledge about the products, organizations, competitors, etc. of the enterprise. A competency ontology is included that captures the competencies that an employee must possess to participate in specific activities of the business processes.

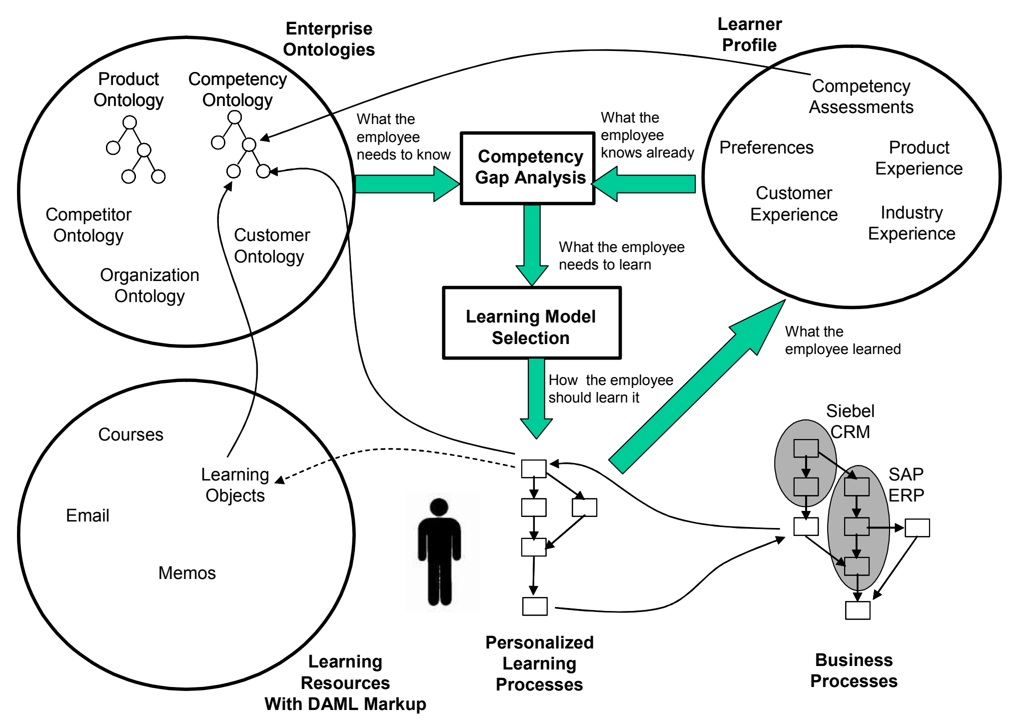

Figure 1: Competency-Based Just-In-Time Learning

The lower left hand corner of Figure 1 illustrates the learning resources such as learning objects, courses, email, etc. Each of these learning resources has been manually or automatically linked to various parts of one or more of the enterprise ontologies to enable people and software agents to more efficiently discover the correct learning resources. The upper right hand corner illustrates the learner profile for an employee that contains preferences, experiences and assessments of the employee's competencies.

The box in the upper middle of Figure 1 is a competency gap analysis that calculates what competencies the employee lacks to effectively carry out their job responsibilities. This calculation is based on what the employee needs to know and what they already know. Once the competency gap has been identified, a learning model is selected either manually or automatically. This establishes the best way for the employee to attain the competency and enables the system to create the personalized learning process at the lower middle of Figure 1. The personalized learning process may be created and stored for later use or it may be created whenever it is needed, thus enabling dynamic access to learning objects based on the most recent information about the learner and the environment. The results of the personalized learning process are then returned to the learner's profile.

This system will enable the integration of personalized learning processes with the other business processes of the enterprise, thus enabling continuous learning to become an integral part of the processes of the corporation. The following sections will describe the technologies necessary to implement the system described here and the state of each of the technologies.

2. Web Services

Each box in the business processes and the personalized learning processes in Figure 1 is an activity. These activities might be implemented as existing legacy applications or new applications on a variety of hardware and software systems. In the past, it would have been difficult to integrate applications executing on such heterogeneous systems. But the development of a set of technologies referred to as *web services* [W3C01a] [Glass01] has simplified this integration. The most important of these technologies are Service Oriented Architecture Protocol (SOAP), Universal Description, Discovery and Integration (UDDI) and Web Services Description Language (WSDL). IBM and Microsoft have both agreed on the specifications for these technologies making it possible to integrate UNIX and Microsoft systems.

SOAP is a technology for sending messages between two systems. SOAP uses XML for representing the messages and HTTP is the most common transport layer for the messages. UDDI is a specification for an online registry that enables publishing and dynamic discovery of web services. WSDL is an XML representation that is used for describing the services that are registered with a UDDI registry. Many vendors of enterprise applications such as ERP and CRM are now providing web service interfaces to their products. Once developers of learning objects and learning management systems begin to provide web service interfaces to those objects, it will be possible to dynamically discover and launch learning objects as services on heterogeneous systems.

3. Semantic Web Services

UDDI and WSDL have limited capability for representing semantic descriptions of web services. The discovery of services is limited to using restricted searches of keywords associated with the service. This is insufficient for the discovery of learning objects. But there a number of efforts underway to improve this situation.

The World Wide Web consortium has initiated an effort to develop specifications for a *semantic web* [W3C01b] where web pages will include semantic descriptions of their content. One result of this effort has been the Resource Description Framework (RDF) model for describing the contents of a web page [W3C01c]. The US Defense Advanced Research Projects Agency (DARPA) has also been sponsoring research as part of the DARPA Agent Markup Language (DAML) program [DAML02] [McIl01]. This program has focused on the development of a semantic markup language DAML+OIL based on RDF for web pages that will enable software agents to understand and reason about the content of web pages. The program has also developed a markup language for web services called DAML-S [Anko01] that enables an improved semantic description of a web service.

The e-Learning industry is developing metadata standards for describing the semantics of learning objects [IEEE01]. The Advanced Distributed Learning (ADL) Lab with sponsorship from the Department of Defense has developed an XML representation of this metadata as part of the Shared Content Object Reference Model (SCORM) specification [SCORM02]. There is also an RDF representation of the learning object metadata [Dhra01] which should enable a DAML markup for learning objects and a DAML-S markup for learning object services.

4. Competency Ontologies

The concepts, relationships and processes of an enterprise can be captured in a set of enterprise ontologies. Ontology representation and reasoning systems are available [Lena95] and the DARPA DAML program has also done significant research on the representation of ontologies in RDF. They have developed a large number of ontologies that can be referenced by the DAML markup language associated with a web page in order to clarify the semantics of the web page.

A few commercially available e-learning products use competency hierarchies to capture the skills necessary for various job types. The competencies in these hierarchies are then mapped to courses that can improve an employee's competency in a certain area. There is no industry standard representation for these competency hierarchies although there have been some efforts to create such a standard [HRXML01]. These existing competency representations do not capture the rich semantics that could be captured using an ontology representation. A competency ontology can capture the relationships among various competencies and relationships with other ontologies, such as the product ontology for a corporation. A competency ontology will also allow reasoning about the competencies.

5. Representation of Business Processes and Learning Processes

A key requirement for the success of the system in Figure 1 is the ability to explicitly represent the processes in the enterprise. There must be a representation for the business processes so that competencies can be mapped to a specific activity in a business process. There must be a representation of personalized learning processes to enable integration of these learning processes with business processes.

There have been various attempts to standardize the representation of business processes [Cich98] [WFMC01] [BMPL02]. There are now numerous efforts underway to standardize on a process representation for web services. At present, IBM and Microsoft have competing proposals for a process representation [WSFL01] [XLANG01]. There has also been an effort within the DARPA DAML program and the DARPA CoABS [CoABS02] program to standardize on a more semantically expressive representation of processes.

6. Software Agents

There is a huge potential for the effective deployment of autonomous software agents in a system such as the one described in Figure 1. In the past, there has been extensive research into the use of software agents for discovery of information [Woel94], collaboration planning and automation of processes [Tate96] and numerous other applications [Brad97]. This research is now focusing on the use of software agents with web services [Hend01]. Once the semantics of the services and processes in Figure 1 have been adequately described, autonomous software agents can be much more effective. These agents can proactively search for learning objects both inside and outside of the enterprise that are needed to meet dynamically changing learning requirements. Furthermore, the role of simulations as a technique for training will be increased [Shan97]. Developing a simulation of a business process using software agents will be simplified and the simulations can be integrated more directly with the business processes.

7. Conclusions

This paper has described a proposed system for competency-based just-in-time learning in a corporate environment that leverages the latest advances in open, standards-based distributed computing and the latest advances in semantic markup of web content and web services. These advances are rapidly moving the World Wide Web towards becoming an environment for large, complex, applications based on dynamically configured sets of services executing on heterogeneous computing platforms. e-Learning applications designed for and implemented in this environment can begin to deliver on the vision of delivering personalized learning experiences that increase the effectiveness of employees in meeting corporate objectives.

References

[Anko01] Ankolekar, A., etal. "DAML-S: Semantic Markup for Web Services", http://www.daml.org/services/SWWS.pdf

[BPML02] Business Process Modeling Language, Business Process Management Initiative, www.bpmi.org

[Brad97] Bradshaw, J. *Software Agents*, MIT Press, 1997.

[Cich98] Cichocki, A., A. Helal, M. Rusinkiewicz and D. Woelk. *Workflow and Process Automation: Concepts and Technology*, Kluwer Academic Publishers, 1998.

[CoABS02] DARPA Control of Agent Based Systems Program, http://www.darpa.mil/ito/research/coabs/

[DAML01] DARPA Agent Markup Language Program www.daml.org

[Dhra01] Dhraief, H., W. Nejdi, B. Wolf and M. Wolpers. "Open Learning Repositories and Metadata Modeling", Semantic Web Working Symposium, July 2001.

[Glass01] Glass, G. *Web Services: Building Blocks for Distributed Systems,* Prentiss Hall, www.phptr.com, 2001.

[Hend01] Hendler, J. "Agents and the Semantic Web", IEEE Intelligent Systems Journal, March/April 2001.

[HRXML01] HR-XML Consortium Competencies Schema,

http://www.hr-xml.org/subchannels/Competencies/index.htm

[IEEE01] IEEE LTSC, 2001 "Draft Standard for Learning Object Metadata" IEEE P1484.12/D6.0

[Lena95] Lenat, D. "CYC: A Large-Scale Investment in Knowledge Infrastructure", Nov. 1995, Vol. 38 No. 11, Communications of the ACM, 1995.

[McIl01] McIlraith, S., T. Cao Son and H. Zeng, "Semantic Web Services", IEEE Itelligent Systems, March/April 2001.

[SCORM02] Advanced Distributed Systems (ADL) Lab, Sharable Content Object Reference Model (SCORM), www.adlnet.org

[Shan97] Shank, R. Virtual Learning: A Revolutionary Approach to Building a Highly Skilled Workforce", McGraw-Hill, 1997.

[Tate96] Tate, A. "Representing Plans as a Set of Constaints – the <I-N-OVA> Model", Proceedings of the Third International Conference on Artificial Intelligence Planning Systems (AIPS-96), 221-228, AAAI.Press, Menlo Park, CA

[WFMC01] Workflow Management Coalition, www.wfmc.org

[Woel94] Woelk, D. and C. Tomlinson, "The InfoSleuth Project: Intelligent Search Management via Semantic Agents", Second International World Wide Web Conference, October, 1994.

[WSFL01] Web Services Flow Language, IBM,

http://www-4.ibm.com/software/solutions/webservices/pdf/WSFL.pdf

[W3C01a] World Wide Web Consortium Web Services Activity www.w3c.org/2001/ws

[W3C01b] World Wide Web Consortium Semantic Web Activity www.w3c.org/2001/sw

[W3C01c] World Wide Web Consortium Resource Description Framework (RDF) www.w3c.org/rdf

[XLANG01] "XLANG: Web Services for Process Design", Microsoft http://www.gotdotnet.com/team/xml_wsspecs/xlang-c/default.htm