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Supporting Interoperability and Context-Awareness in E-Learning through Situation-Driven Learning Processes

Stefan Dietze, Open University, UK

Alessio Gugliotta, Open University, UK

John Domingue, Open University, UK

ABSTRACT

Current E-Learning technologies primarily follow a data and metadata-centric paradigm by providing the learner with composite content containing the learning resources and the learning process description, usually based on specific metadata standards such as ADL SCORM or IMS Learning Design. Due to the design-time binding of learning resources, the actual learning context cannot be considered appropriately at runtime, what limits the reusability and interoperability of learning resources. This paper proposes Situation-driven Learning Processes (SDLP) which describe learning processes semantically from two perspectives: the user perspective considers a learning process as a course of learning goals which lead from an initial situation to a desired situation, whereas the system perspective utilizes Semantic Web Services (SWS) technology to semantically describe necessary resources for each learning goal within a specific learning situation. Consequently, a learning process is composed dynamically and accomplished in terms of SWS goal achievements by automatically allocating learning resources at runtime. Moreover, metadata standard-independent SDLP are mapped to established standards such as ADL SCORM and IMS LD. As a result, dynamic adaptation to specific learning contexts as well as interoperability across different metadata standards and application environments is achieved. To prove the feasibility, a prototypical application is described finally. [Article copies are available for purchase from InfoSci-on-Demand.com]

Keywords: Context-Awareness; E-Learning; Interoperability; Semantic Web Services; WSMO

INTRODUCTION

The increasing availability of learning resources raises the need to discover and deliver the most appropriate learning resources to the learner to satisfy his/her learning needs within the actual learning situation. A learning *situation* constitutes the actual *context* which has to be addressed and is defined by e.g. the used technical environment or specific learner characteristics such as his/her native language.

The current state of the art in E-Learning is mainly represented by approaches based on software systems, such as *learning content manage-*

ment systems (LCMS) which provide a learner with composite learning contents – the so called *learning objects (LO)*. Usually, a LO contains a description of a learning process - the learning path which has to be followed by the learner to fulfil his current learning objective – which is referred to a set of learning resources, whether these are data or services. Interoperability between LCMS is currently supported through metadata standards such as IEEE LOM (Duval, 2003), ADL SCORM (ADL SCORM, 2004) – based on IMS Simple Sequencing - or IMS Learning Design (IMS LD) (IMS Global, 2003) supporting the description of learning processes as well as learning objects. To satisfy a given learning need, a learning designer manually describes the learning process and allocates learning resources. Even though current E-Learning metadata standards try to address dynamic context-adaptability by introducing facilities such as the IMS LD Level B properties, their capabilities are limited and still rely on the manual pre-allocation of resources and a pre-defined selection strategy. Due to the design-time binding of learning process and learning resources, the actual runtime context of the learning process cannot be considered appropriately and therefore, a learning object cannot adapt dynamically to the specific context or learner needs. Consequently, reusability of a LO across distinct learning contexts or E-Learning applications is limited.

The use of *Web services* instead of data addresses these issues partially. However, since Web services are deployed using purely syntactic technologies such as SOAP (W3C, 2003a), WSDL (W3C, 2001), and UDDI (W3C, 2003b), which do not provide information about the semantic meaning of the service functionalities, utilized data or usage constraints, services cannot be discovered, composed and invoked automatically. *Semantic Web Services (SWS)* technology (Fensel et al., 2006) aims at the automatic discovery of distributed Web services as well as underlying data on the basis of comprehensive semantic descriptions utilizing ontologies (Gruber, 1995) as formal specification of a service conceptualization. First results of SWS research are available, in terms of reference ontologies – e.g. OWL-S (Joint US/EU ad hoc Agent Markup Language Committee, 2004) and WSMO (WSMO Working Group, 2004) – as well as comprehensive frameworks - e.g. DIP project results (http://dip.semanticweb.org) - and applications. Whereas existing SWS frameworks enable the semantic description of Web services and data exposed by a Web service, they do not entirely encourage the representation of learning situations and processes, in which resources are used. In other words, SWS descriptions represent a process from a system perspective as an orchestration process which involves the invocation of services and the manipulation of data. In contrast, process metadata descriptions such as IMS LD or ADL SCORM provide non-semantic descriptions about a learning process from a user perspective.

The approach described in this paper bridges the gap between learning situations and resources based on semantic *Situation-driven Learning Processes (SDLP)* that consider the user as well as the system perspective of a process. Learning processes are described as sequences of learning goals which lead from an initial to a final situation, where each goal is supported through dynamic SWS goal invocations. SDLP are composed dynamically and accomplished by automatically allocating learning resources (data, services) at runtime to adapt to different learning contexts. To achieve this vision, our approach is based on the following principles: abstraction from learning resources and semantic contextualization of learning process models.

The abstraction from the actual resources – data as well as services – supports the semantic representation of the system-perspective of a process through established SWS technology and is aimed at the automatic discovery of resources which provide the required capabilities for a given context. Based on semantic descriptions of functional capabilities of available Web services, a SWS broker automatically selects and invokes Web services appropriate to achieve a given user goal. The contextual-