An Adaptive and Context-Aware Architecture for Future Pervasive Learning Environments

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I. Introduction

Nowadays, technology-enhanced learning systems can be build on learning management systems (LMS) or personal learning environments (PLE). On one hand, LMS provide administrative services (admissions, registration, etc.), trace tools of learners activities accessible for teachers, and serveral tools (discussion forums, file sharing, management of assignements, learning activities, chat, etc.). The main drawbacks are that those tools are pre defined and the correspond pedagogical approaches are implicitly frozen, thus choice is limited, and that they are bounded to a local area of participants.

On the other hand, PLE are distributed, personnalized and composed of separated tools, social media applications. From an educational perspective, social media applications including blogs, wikis, rich media sharing, etc. fit well with socio-constructivist learning approaches as they provide spaces for collaborative knowledge building and reflective practices. These social media tools are used in informal learning settings commonly found outside formal and institutional learning environments. In PLE, learning objects are distributed on the web in different tools that do not provide interoperability; activities are implicit and difficult to monitor; learners traces are almost impossible to get. Those environments are at present exclusive (Dalsgaard 2006).

Moreover, pervasive learning is recently becoming an important issue in technology-enhanced learning field. Pervasive computing has the ability to increase our capability to physically move computing tools and services with us and to inquire, detect and explore the surrounding environment in order to obtain information and to dynamically build context models that allow for supporting different aspects of the learning process (Lyytinen and Yoo 2002). For instance, computers can obtain information about the context of learning from the learning environment where small devices, sensors, pads, badges, learners, teachers or tutors, communities and so on, are embedded and communicate mutually. The physical environment is directly related to learning goals and activities. New situated learning activities may be achieved to enhance the learning process that were difficult to realized before (even impossible before). Context based activities, or pervasive learning, imply the ability to provide the right content, with the right tool within a well suited activity. Social interaction in such context make necessary the interoperablity of data across tools. Assessment of activities (either formative or summative) call for learning trace access. All of this also means that pedagogical activities should be adapted on the fly in an open, distributed environment, requires the definition of models, based on knowledge models and pedagogical theories, used by a distributed adaptation framework.

A major challenge for future technology-enhanced learning systems is to combine the benefits of learning management systems, personal learning environments, social media software and pervasive learning environments. According to recent studies, technology-enhanced learning (TEL) systems must have the capability to reuse learning resources and web services from large repositories, to take into account the context and to allow dynamic adaptation to different learners based on substantial advances in pedagogical theories and knowledge models (Balacheff 2006). It is particularly true in pervasive learning. The reuse of learning resources and/or data requires interoperability at semantic level. In other words, it is necessary to have a semantic web approach to design TEL systems. Moreover, knowledge models and pedagogical theories can be fully represented by means of a semantic web approach.

Unfortunately, learning management systems and social media applications are data silos. In other words, data are unavailable on the web. Only people may have access to data, not computers. Reuse and exchange of data among LMS and social tools are only possible by means of API – that is to say manually by mean of one API per tool. On the contrary, semantic web provides a common framework that allows data, information and knowledge to be shared and reused across applications, enterprises, and community boundaries. In such a framework, linked data describes a method of exposing, sharing, and connecting data, information and knowledge on the Web (Bojaars, Breslin et al. 2008; Gruber 2008). It provides a standardized, uniform and generic method for data discovery, distributed queries against several data repositories, integration or semantic mash-up, uniform access to metadata, data, information and knowledge. Some metadata can be generated automatically (sometimes on the fly) from the tool databases according to common vocabularies like Dublin Core, SKOS, SIOC, FOAF, etc. Most of these vocabularies are lightweight ontologies that can fit well database schemas. These vocabularies provide common semantic enabling computers to put queries on LMS and social media tools. Thus, the web can be viewed as a single global database. Users and/or computers can perform complex queries against this global database using the SPARQL language. Complex queries are queries over multiples pages / web sites / data repositories whatever the tool is. It only has to expose data on the common standard and vocabularies. Thus, future pervasive learning environments can be composed of lots of different LMS, social media tools exposing, sharing and connecting data, information and knowledge on the web.

Our vision is that future pervasive learning environments will be based on contextual adaptation of pedagogical activities and resources based on a semantic web approach to provide on the fly the distributed software environment, composed of appropriate standards tools, to enable the fullfillment of proposed or chosen assessable activities in a social environment.

II. Problems to solve

First of all, we highlight some functionalities that could be available by means of linked data. A tutor and/or a learner may gather the outcomes of learners' activities across multiple sites or relevant resources and tools may be recommended to a learner taking into account his social network and interests and/or his learning communities as found in social and learning web applications. Information available in a learner social networks and learning communities could be used to enrich his context features. Ontologies, like SIOC and FOAF, enable us to provide these type of functionalities. The related metadata are computed on the fly, for instance by

specific plugins in social web applications. These ontologies fit well the corresponding attributes of social web databases.

Nevertheless, these ontologies are not sufficient to achieve all functionalities required to build future pervasive learning environments. Fulfilling this vision requires to solve a number of technical and pedagogical issues. Some of these issues are as follows:

1. Learning resources and web services retrieval
2. Pedagogical issues: activity modeling and management
3. Context modelling, management and adaptation policies

Learning resources and web services retrieval

At present, learning ressources are not indexed by means of semantic metatdata. To retrieve relevant resources, it is necessary to have at least a domain ontology modeling the topics of interest related to the learning goals and, of course, to setup corresponding metadata. In most of the cases, it is not possible to do it automatically. Specifc tools has to be developed to suggest relevant metadata to users.

Pedagogical issues: activity modeling and management

Activities have to be structured, coordinated and explictly represented in order to manage them and to define their relevant contexts.provide At least, two complementary approaches could be used: i) Recommendation of a priori defined and well structured activities that may be achieved in different ways according to the current situation; ii) Recommendation of activities and learning ressources according to the current situation. Consequently, ontologies must be designed to represent and manage learning activties. In future pervasive learning environments, an activity may be achieved in different tools and a tool can be used to accomplish different activties. It is necessary to link activities and tools to be able to monitor and to support learners according to context and learning goals.

Enrichment and management of context

Dourish (Dourish 2004) claims that context arises from the activities and cannot be separated from them. It is actively produced, maintained and enacted during activities. We claim that activities embedded in a particular physical world (or environment) are key issues to give us intention and meaning according to different situations and finally to determine the relevant features describing the different situations. Many definitions of context are given in literature. We mainly focus on some of them: *"learning context is used to describe the current situation of a person related to a learning activity; in addition to attributes relying on the physical world model* (Derntl and Hummel 2005); *" information and content in use to support a specific activity (being individual or collaborative) in a particular physical environment"* (Kurti, Milrad et al. 2006).

An history of learners and/or tutors activities across social web applications can be retrieved and/or discovered, as all user activities are time recorded. Such history could be used to manage seamless learning and learning across context issues. In the mid-time, the Semantic Sensor

Network Incubator Group would provide ontologies that define the capabilities of sensors and sensor networks and develop semantic annotations of a key language used by services based sensor networks (http://www.w3.org/2005/Incubator/ssn/). Acquire data from network sensors at knowledge level will also enrich the learner context features.

III. Conclusion

Our vision is that future pervasive learning environments will be based on contextual adaptation of pedagogical activities and resources based on a semantic web approach to provide on the fly the distributed software environment, composed of appropriate standards tools, to enable the fullfillment of proposed or chosen assessable activities in a social environment.

In order to achieve this new generation of learning environments, appropriate ontologies for semantic web should be defined to enable development of new pervasive pedagogical activities and usage in an open environment shared between new generation of learners, teachers and learning communities.

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