Learning in Ubiquitous Computing Environments

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ABSTRACT
The application of ubiquitous technologies in the improvement of education strategies is called Ubiquitous Learning. GlobalEdu is a model created to support ubiquitous learning. The model has the necessary support to implement learning-related functionalities in ubiquitous environments. The basic ubiquitous computing support must be supplied by a middleware where GlobalEdu lays atop. This article proposes the GlobalEdu model and its integration with two ubiquitous middlewares: ISAM and LOCAL. ISAM supports the creation of large-scale ubiquitous systems. As such, its integration with GlobalEdu results in large-scale ubiquitous learning environments. LOCAL is dedicated to create small-scale ubiquitous learning environments. The integration GlobalEdu/LOCAL results in a local ubiquitous learning environment. Based on this small-scale environment, the authors created a system and applied it in a practical scenario involving the community of a Computer Engineering undergraduate course. The system was positively evaluated by 20 individuals and the initial results attest the system’s usefulness.

Keywords: Context-Aware Computing, Location Systems, Mobile Computing, Ubiquitous Computing, Ubiquitous Learning

INTRODUCTION
In recent years, studies about mobility in distributed systems have been stimulated by the proliferation of portable electronic devices (for example, cell phones, handheld computers, tablet PCs and notebooks) and the use of interconnection technologies based on wireless communication (such as WiMAX, WiFi, and bluetooth). This mobile and distributed paradigm is called Mobile Computing (Diaz, Merino, & Rivas, 2009; Satyanarayanan et al., 2009). Moreover, the improvement and proliferation of Location Systems (Hightower & Borriello, 2001; Hightower & Smith, 2006) have motivated the adoption of solutions that consider the user’s precise location for the provision of services, Location-Based Services (Dey et al., 2010; Vaughan-Nichols, 2009).

The adoption of these technologies combined with the diffusion of sensors enabled the availability of computational services in specific contexts — Context-aware Computing (Baldauf, Dustdar, & Rosenberg, 2007; Dey, 2001; Hoareau & Satoh, 2009). The idea consists in the perception of characteristics related to the...
users and their surroundings. These characteristics are normally referred to as context, i.e., any information that can be used to describe the circumstances concerning an entity. Based on perceived context, the application can modify its behavior. This process, in which software modifies itself according to sensed data, is named Adaptation (Satyanarayanan, 2001). In this scenario, the Ubiquitous Computing initially introduced by Abowd and Mynatt (2000), Satyanarayanan (2001), and Weiser (1991) is becoming reality.

The application of mobile and ubiquitous computing in the improvement of education strategies has created two research fronts called Mobile Learning and Ubiquitous Learning. Mobile learning (m-learning) (Tatar, 2003) is fundamentally about increasing learners’ capability to carry their own learning environment along with them. M-learning is the natural evolution of e-learning, and has the potential to make learning even more widely accessible. However, considering the ubiquitous view, mobile computers are still not embedded in the learners’ surrounding environment, and as such they cannot seamlessly obtain contextual information.

On the other hand, Ubiquitous Learning (Barbosa et al., 2007; Lewis et al., 2010; Ogata & Yano, 2009; Ogata et al., 2010; Rogers et al., 2005; Yin, Ogata, & Yano, 2004; Yin et al., 2010) refers to learning supported by the use of mobile and wireless communication technologies, sensors and location/tracking mechanisms, that work together to integrate learners with their environment. Ubiquitous learning environments connect virtual and real objects, people and events, in order to support a continuous, contextual and meaningful learning. A ubiquitous learning system can use embedded devices that communicate mutually to explore the context, and dynamically build models of their environments. It is considered that while the learner is moving with his/her mobile device, the system dynamically supports his/her learning by communicating with embedded computers in the environment. The opportunities made available by the context can be used to improve the learning experience.

This learning scenario is attractive, but is not easily implemented. We are investigating how to better match people’s expectations for such a system. In our point of view, ubiquitous learning environments should support the execution of context-aware, distributed, mobile, pervasive and adaptive learning applications.

GlobalEdu is a model created to support ubiquitous learning. The model is structured into layers and can also be coupled with a ubiquitous computing middleware. This article proposes the GlobalEdu Model and its integration with two ubiquitous middleware projects: ISAM (Augustín et al., 2004) and LOCAL (Barbosa et al., 2007).

The ISAM project focuses on the building and management of large-scale ubiquitous computing environments (Augustín et al., 2004), and is being developed at UFRGS (Federal University of Rio Grande do Sul, Brazil). The integration GlobalEdu/ISAM results in a large-scale ubiquitous learning environment.

On the other hand, LOCAL aims to support small-scale, location-and-context-aware computing environments. It is being developed at University of Vale do Rio dos Sinos (UNISINOS, Brazil). Integrating GlobalEdu and LOCAL we have a small-scale ubiquitous learning environment. This integration was fully implemented and it was applied in a practical experiment to evaluate the system’s usability. In this evaluation we involved the community of a specific Computer Engineering undergraduate course at UNISINOS.

This article is organized in six sections. The next section details the model GlobalEdu. The following section proposes the integration between GlobalEdu and the middlewares. The fourth section approaches a full implementation of the GlobalEdu/LOCAL integration and describes the experiment used to evaluate our proposal. The fifth section presents previous work in the area of ubiquitous technology used to create pedagogical applications, and how it relates to our work. Finally, in the last...
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