Learning in a Large-Scale Pervasive Environment

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Abstract

The idea of pervasive learning is to create a network of devices, people and situation that allow learning experiences to play out. This idea is attractive, but is not easily implemented. This paper presents a pervasive learning architecture called GlobalEdu which is composed by Educational Services (ES) and Pervasive Personal Pedagogical Agent (P3A) implemented above the ISAM platform. It is a software architecture that manages a large-scale pervasive environment. ES expands the ISAM services to educational domain to provide knowledge management, context management, control and communication. P3A is shall always be with the learner, assisting the process of learning, independent of user's device at the moment.

1. Introduction

The increasing use of mobile devices, the Internet, and wireless network designs a scenario where computing will be global. The mobility of the user requires new models of applications for computational power spread all over the net, nonresident in a device that has the sporadic capacity of communication, and stores and executes software. This is the pervasive computing [10]. In this, the user is free to move anywhere, anytime and having access to his/her virtual computing environment. The essence is that the user's applications are available in a suitable adapted form, wherever that user goes. Pervasive Computing is interesting for the development Pervasive Learning because learning can occur anywhere, anytime, with continued computing support. Towards this scenario, some proposals are being developed [2], [6].

In this paper, we describe GlobalEdu learning architecture [15]. We proposal have been developped considering the features and services provided by ISAM software architecture, which focus on building and management of a large-scale pervasive computing environment [1], [13]. GlobalEdu specializes this architecture to educational domain. For that, it is structured in two kind of components: Educational Service (ES) and a Pervasive Personal Pedagogical Agent (P3A).

This paper is organized as follows: Section 2 presents the definitions and standards associated with this work. Section 3 describes the objectives of the ISAM project. Section 4 details the GlobalEdu proposal. Section 5 describes the applications for to evaluate the proposal. Section 6 concludes the paper and presents the plans for future works.

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2. Background

Several projects were started to investigate the use of web technology, adaptative technical learning, and access to educational servers. Elena [11] is an operational learning services network based on the interoperable communication infrastructure named "smart spaces for learning". The SeLeNe [9] project offers advanced services for the discovery, sharing and collaborative creation of learning resources, as well as a personalized access to such resources.

E-Learning metadata standards constitute formal specifications of the descriptive terms used to semantically annotate educational material of all kinds or learner information. For this, we are using some PAPI [7] and LIP [5] standards elements. Your learner model proposal is increasing with learning styles [3] and learner history (trails). E-Learning applications are based on the transmission of learning content across various computing environments and platforms; hence, what has to be specified is a structure unit suitable for this interoperation. This "learning unit" is called a Learning Object (LO). From the variety of the e-Learning standards proposed from time to time, this work is using IEEE LOM standard [4].

Mobile learning is fundamentally about increasing learners' capability to physically move their own learning environment with them. In this situation, however, computers are not embedded in learner's surrounding environment, and they cannot seamlessly and flexibly obtain information about the context of his/her learning. Works such as [8] and [12] have used mobile learning technology.

In pervasive learning, computers can obtain information about the learning context from the learning environment, where small devices are embedded and communicate mutually. A pervasive learning environment can be built either by embedding models or by building generic capabilities into computers to inquire, detect, explore, and dynamically build models of their environments. Our work does not consider embedded computers in the environment. We consider that environment systems support distributed, mobile, context-aware, adapted and follow-me learning applications.

Considering a pervasive perspective and based on several works, one of the characteristics of learning in this environment is that the daily context of the user can be connected with the social context, joining current information with educational objectives. For our work, social context is the information about persons, events and resources in the specific location.

For us, pervasive learning is attractive, but is not easily implemented. We are investigating how provide a support for assisting to this expectative. In your point of view, a pervasive learning environment can be support the execution of context-aware, distributed, mobile and adaptative educational applications. Differently from other researches [2], [6] GlobalEdu [15] is a proposal that support these applications.

3. ISAM project

Pervasive Computing is the scope of ISAM project[1] [1], [13]. This aims to study alternatives to simply the design and execution of the pervasive applications with physical and logical large-scale mobility. The ISAM software architecture (Figure 1) is composed by a middleware that provides sypport to program large-scale pervasive applications, and it also manages the application execution at global scope. To develop mobile wide-area applications, we consider that mobile hosts must use the existing and accessible fixed network infrastructure, and they have to take advantage of the environment such as the Internet.

The ISAM application model considers that "the computer" is the whole network. The computing environment (data, device, code, service, resource) is spread in composed cells. Users can move around, having both their applications and virtual environment following them [14]. GlobalEdu investigates how to expand the ISAM architecture to e-learning domain. This raises the key question as to what subset of functionality is required on pervasive learning in order to achieve the benefits of large-scale pervasiveness.

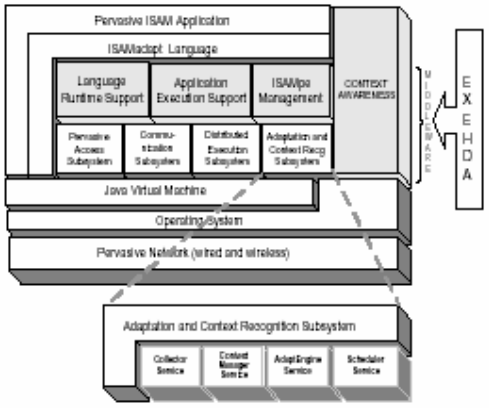

Figure 1. ISAM Software Architecture

[1] ISAM project is supported in part by CNPq, RNP and FINEP Brazilian Foundations

4. GlobalEdu

GlobalEdu [15] is a pervasive learning architecture that supports learning applications using the large-scale pervasive environment managed by ISAM architecture. Figure 2 presents the GlobalEdu architecture. It is composed by three layers: P3A, SE e ISAM pervasive architecture. P3A is an agent that moves itself to the device that the learner is using, assisting the educational process in the pervasive environment. The behavior of the P3A is defined by the learner model, learner context and learning object model. ES provides the support to P3A execution in the large-scale pervasive environment, through the identification and adaptation of the resources in agreement with the learner's educational model.

In the view point of ISAM archiecture, GlobalEdu is instanced as an pervasive application. So, GlobalEdu make use of ISAM services to obtain context information, to access the available resources, to migrate the agent, to discover resources, etc. The ISAM architecture also influenced the organization of GlobalEdu components spliting its functionalities in nodal and celular instance (Figure 2). P3A is a node instance in the ISAM that executes in the mobile devices, for instance. So, P3A is not weight unit execution. SE are a celular instance in the ISAM that execute in computers of the network, assisting the P3A execution and interface with ISAM architecture. Because this, SE can be a weight unit execution.

4.1. Pervasive Personal Pedagogical Agent (P3A)

The P3A characteristics are: (1) migration to the devices in use at moment by the learner; (2) communication with the ES to obtain environment's information; (3) control of disconnection, operating normally in the accompanying of the learner, despite some access restrictions to the ES and within the capabilities of the device; (4) control of access of the learning objects and context information, related to the location of the learner with learning goals.

P3A contains micro-agents responsible for assisting in the process of educational adaptation:

- *P3A Learner Model* - It represents the information about the tutored learner, represented by metadata, in the educational adaptation. It is assisted by the *ES Learner Model*.
- *P3A Knowledge Management* - It helps the learner with the search and shows the learning object according to the physical context information and learner model. The *ES Knowledge Management* assists the *A3P Knowledge Management* activity.
- *P3A Context Management* - It presents the social context information according to the learner model and the physical context information. The *ES Context Management* assists the *A3P Context Management* activity.
- *P3A Control* - It is assisted by the *ES Control* and is responsible for executing the local procedures to support the physical mobility of the P3A, as well as perceive the changes of the context elements that integrate the different locations of the learner carrying the device;
- *P3A Communication* - it manages the external exchange of messages sent and received by the P3A to the ES. Upon receiving a message, it is evaluated and directed to the destination micro agents.

P3A acts in two modes: cognitive, based on beliefs; and reactive, based on events. The beliefs, considered the knowledge of the learner's current state and used by the ES in the composition of the production rules, being this formalism used for the reasoning of P3A. Events constitute the stimuli necessary for the reaction to the specific transformations seen during processing, characterized by the messages exchanged internally by the P3A micro-agents.

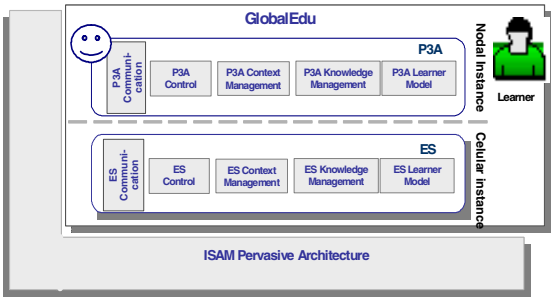

Figure 2. GlobalEdu Architecture

3.2. Educational Services (ES)

ES use the services provided by ISAM architecture for assisting to the P3A. They are responsible by extend the ISAM services to learning domain. It characterizes and generates educational information, according to the needs and context in which the learner is, defining the most suitable pedagogical model. It is composed of pedagogical goals and strategies which a LO tends to attend. The

pedagogical strategies to be used follow the Learning Styles proposed by Felder-Silverman [3]. The pedagogical goals of a LO are the competencies to be developed through the study of the object. Also, through the information referring to the social context, adaptation is responsible for linking the information of the local where the learner is with the learner's educational goals. Physical context information, device adaptation and repositories control are supported by ISAM services [13].

3.2.1. ES Learner Model. When learner moves, yours model can change. The *ES Learner Model* is responsible for generate the learner model, represented by metadata which use PAPI and LIP standards, Learning Styles and Trails. The PAPI categories that we have used are Personal Information, Preferences, Relations and Security. The LIP categories used are Goal and Competency. The Learning Styles category processes information, based on the Felder-Silverman proposal. Trails is the learner's history in your trajectory in the pervasive environment. This is composed by information about location, device and context acessed by the learner. This way, it will be possible to infer any alteration in the learner model based on the learner's history.

The information of Relations and Competence was included into this work so as to meet the competencies of P3A in the pervasive environment, besides the information referring to the social contexts accessed by the learner. Learner Model Repositories store the learner's model, represented in XML, and are supported by ISAM service named BDAservice, that implements the pervasive database access.

3.2.2. ES Knowledge Management. It is responsible for managing the Learning Objects (LO) according to the learner model and is supported by the context. This work uses five categories of the IEEE LOM standards: general, life cycle, technical, educational and rights. For our proposal, these categories are interesting for knowledge modeling. The *ES Knowledge Management* assists the *A3P Knowledge Management activity*. Knowledge Repositories store the LO and knowledge metadata and are supported by ISAM. The metadata are represented in XML.

3.2.3. ES Context Magement. It manages information about the learner context, perceiving the changes of the context elements that integrate the different locations where the learner moves with your device. The context can be social or physical. The social context corresponds to the information about people, events and resources about some location. This information is represented with XML metadata and is store at Social Context Repositories. The physical context corresponds to the context of interest of the educational resources accessed by the learner, such as network, location, device and presence of other P3As in the environment. This information composes the Learner Context. The elements that compose the physical context are managed by context recognition system of ISAM architecture. Changes in the state of the context elements are sent to *SE Context Management*.

With the social and physical context, it is possible composed the information that represent the learner context interesting. The information referring to the presence of other P3As in the context in which the learner is currently presupposes the existence of other learners with the same goals, competencies and preferences whose information the learner may access for contact or not. This information can also be used for creation of learner groups within the same context. This information is stored in the Relations category of the Learner Model. The *ES Context Mana*gement assists the *A3P Context Management* activity.

3.2.4. ES Control. *ES Control* uses the ISAM services to manage and execute the migration process and physical mobility and is responsible for executing the procedures to support the physical mobility of the P3A among the several devices used by the learner. This service uses ISAM supports for migration and adaptation code.

3.2.5 ES Communication. *ES Communication* manages the exchange of external messages sent and received by the ESs of the environment. Upon receiving a message, it is evaluated and directed to the local destination agents. For this action, *ES Communication* uses ISAM communication support.

5. Validations

We are implementing the GlobalEdu in integrated way with the ISAM architecture, aiming the validation of the proposed architecture. A prototype pervasive environment is being create using the resources make available by UNILASALLE, UFRGS, UFSM and UNISINOS brazilian universities. This activity will encompass the organization of the physical support to execute pervasive learning applications around the

campuses. With this, it will be possible for users to change of context keeping continuous computing.

For to evaluate the proposal, we will develop three applications: MeetAgent, ContextAgent and LibAgent. Basically, these are simplified versions of the P3A and SEs to validate the learner, knowledge and context model's. MeetAgent identifies others MeetAgents in the environment, suggesting to the learner other learners with the same interests. ContextAgent relates social context with learner, using his position and the learner model. LibAgent identifies learning objects in network repositories, using the learner's model. The agent controls the learning objects manipulation and presentation too. The platform used by implementation is Java in the J2SE and J2ME versions.

6. Conclusions

GlobalEdu is a inovative proposal that will allow exploring the benefits of pervasive environment with learner's mobility at global scale. The GlobalEdu architecture is splited in two parts: Pervasive Personal Pedagogical Agent (P3A) that accomplishes the learner in your path, and Educational Services (ES) that makes the interface between the agent and the services provided by ISAM architecture. This proposal contributed by identifying the functionalities required by large-scale pervasive environment in educational domain.

We argue that GlobalEdu will allow the exploration of new applications where the learner is submetted to continuos learning activities anywhere, anytime and using anydevice. Differently from other researches, the proposal supports the execution of context-aware, distributed, mobile and adaptative educational applications. Moreover, the integration with ISAM platform is extremely interesting because it supports a stabilized large-scale pervasive environment. Because this, our proposal supports global communication and continuous computing.

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