Providing Access to Students with Disabilities and Learning Difficulties in Higher Education through a Secure Wireless Framework

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Abstract: *In this paper we focus on the design and implementation of adaptive learning environments in Higher Education, accessible by students with disabilities and learning difficulties. Assistive technology, and especially mobile learning, is used for the establishment of the communication between learner and teacher, mainly, in the mainstream class. We discuss the establishment and operation of parallel "assistive" classes for specific topics and specific groups of students and needs. The architecture of Secure Wireless Infrastructures and Personalized Educational Learning Environments (SWI_PELE) is also presented and the collaboration of such environments is discussed. This architecture includes a scheme of servers and incorporates wireless infrastructure, and personalized, multimedia based educational course material. Mobile devices and PDA's are integrated in educational scenarios to support various activities, such as giving lectures in the mainstream class, attending classes, working in the laboratory and participating in assessments and exams.*

Keywords: *Adaptive learning, Personalized learning, Architecture for educational technology systems.*

I. INTRODUCTION

In Higher Education, students with disabilities and learning difficulties need personalized education in adaptive learning environments. In the e-learning and mobile learning (m-learning) context, the term Assistive Technology (AT) refer to devices, assistive computer programs and computer-based services that help students with disabilities to perform tasks and activities. Therefore, various types and levels of AT for students can include: 1) devices such as Personal Digital Assistants (PDAs) for supporting m-learning, 2) assistive computer programs, such as Text-To-Speech programs reading aloud documents that blind people have typed or dyslexic students retrieved into their computers, 3) Web-based Database Systems and Information Retrieval Systems, such as portals storing lessons, multimedia educational material, bibliography, legislation related to disabilities, news, links to other sources, as well as offering accommodative user interface, personalized access of information, visualization of results, and 4) communication services, such as mobile telephone services that allow a disabled person to communicate with teachers.

In the past the use of AT based services was restricted by the location of use. Lately, PDAs, smart phones and hand held PCs provide a new heterogeneous use of services that includes the whole territory of campus, the town square, etc. (Burzagli *et al*., 2009).

Wireless technology including ad-hoc networks, mobile and ubiquitous environments, offers enhanced, cheap and reliable assistive technology for the Deaf and Hard of Hearing (D-HH) persons. Assistive computer programs can be executed on PDAs; ad-hoc networks of PDAs can offer access to databases of interest; PDAs can ensure communication between users through e-mail, chat, etc. The new networking paradigm that emerged with the appearance of wireless computing can boost the performance of systems in which they get applied. (Belsis *et al*., 2008).

The integration of multimedia features in the teaching content and the application of multimedia enhanced teaching methodologies arise as an interesting challenge (Belsis *et al*., 2005). Combining efficient learner's requirements elicitation with personalization techniques throughout the design and delivery of the instructional material is an extremely important aspect for providing adaptation to the needs and interests of individual learning groups (Belsis *et al*., 2008). Learners with the cognitive disability of dyslexia, and Deaf and Hard-of-Hearing (D-HH) students constitute learning groups which can be greatly benefited by Information and Communication Technologies (ICT). Research on adaptive learning indicated that learner's interests, ability, and cognitive characteristics greatly influence learning effectiveness (Kalyuga, 2007).

Accommodative Learning Environments offer various possibilities of assistance. They, usually, generate the appropriate user profiles, and adapt provision of services and presentations according to these profiles. They combine pedagogical and technological efforts, and use semantics and knowledge to monitor the context of learning (Skourlas *et al*., 2009). AGENT-DYSL programme (Project Agent-DYSL, 2006) aims to support inclusive learning in the mainstream class using text-to-speech programs, spell-checkers and controller, structured presentation of reading, etc. (Schmidt and Schneider, 2007).

This work reports on the design and implementation of a wireless learning system in Higher Education for including students with disabilities and learning difficulties to mainstream class. We present the architecture of Secure Wireless Infrastructures and Personalized Educational Learning Environments

(SWI_PELE) and discuss the collaboration of such environments. Previous work that has been reported includes a brief description of the architecture of Personalized Educational Learning Environments (PELE) (Marinagi *et al*., 2010a) and some experimental results from a first evaluation of the system (Marinagi *et al*., 2010b).

The remainder of this paper is organized as follows: In Section II we firstly present the requirements of system architecture. Then we present various system utilization scenarios, where special emphasis is given to security issues related to the intercommunication between different learning domains and units. In the following we describe the architecture of secure wireless infrastructures for personalized educational learning environments and we explain the role of the servers that were implemented for educational services. Section III presents some conclusions and future perspectives.

II. A FRAMEWORK FOR SWI_PELE

Educational information is highly sensitive in the case of examinations and assessments using PDAs, enrolments, accessing grades, etc.; thus, we have to design our applications in order to demand less processing and network bandwidth resources, without though decreasing our privacy requirements (Skourlas *et al.,* 2009; Vassis *et al.,* 2009).

A. System architecture requirements

The main requirements for Secure Wireless Infrastructures and Personalized Educational Learning Environments (SWI_PELE) are the following:

1) Sensitive educational information and data include answers to specific assignments and exams tests, marks, assessments (and self-assessments) and evaluation (of lectures, students, teachers, and learning cases). Therefore, systems' architecture can provide authorized access and privacy preservation. In order to transmit sensitive data wirelessly a shared key encryption approach must be used so as to achieve a lightweight implementation (Skourlas *et al.,* 2009).

2) Pervasive infrastructures are characterized by Network topology instability due to two factors: node mobility and node failure. System architecture must support and provide constant connectivity for as long as possible. Decentralization of processing and communication tasks are used. This can be done using advanced algorithms which allow the nodes in the network to act collectively as a distributed server (Malatras *et al.,* 2005).

3) For specific sensitive activities, e.g. examinations in the laboratory, administrative services, access control management seems to be important. In order to apply access control, we have also conducted experiments adopting the simple and widely acceptable security standard Role Based Access Control Model (RBAC). This is a standardised model which allows the assignment of permissions to resources according to the role that the user is granted to. For example all students are granted similar permissions (Access specific resources).

4) Integration of the IT infrastructures between learning domains or units and improvement of the collaboration of the learning environment with other ones**.**

B. Utilization Scenarios and Security issues

Fig. 1 illustrates a scalable, distributed architecture, which can support various learning environments and domains. It consists of a wireless network which spans along the campus, and in specific consists of different subnets which communicate, each with its local policy enforcement and authentication module. For access control enforcement and authorization in distributed environments the architecture uses a standardized policy model based on the Role Based Access Control Model (RBAC).

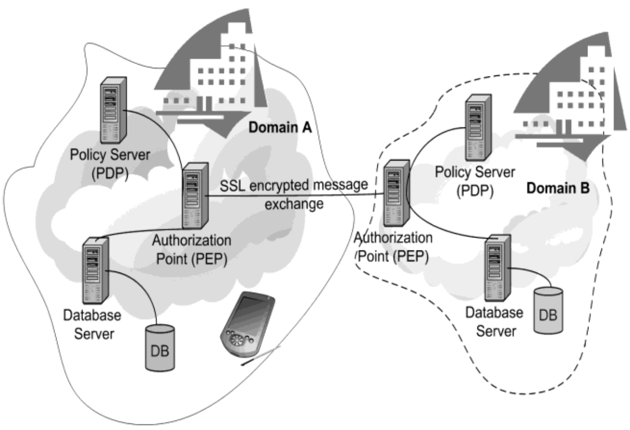

Figure 1. Overview of the secure multi-domain framework of learning environments and infrastructures.

We can present and discuss various System Utilization Scenarios (use cases). A simple, representative one is given:

A D-HH student within the class s/he attends or in her/his place wants to access some basic notes regarding the teacher's presentation or a previous learning unit stored in the multimedia database. The student sends a request from her/his PDA to retrieve the data from the database. Since the requested resource is not a critical one, only the permissions of the requester are evaluated against the local policy and no encryption is used.

In the case of examinations or assignments, when a request is sent to the server, in order to authorize or not the request, the server needs to identify the learner's identity as well as to evaluate the permissions which have been granted to the learner for the specific activity. First it requests a validation of the learner's id.

This can be implemented using public key encryption techniques. Using the learner's public key and the server's private key, the two parties may authenticate each other and they can exchange a (shared) session key which will be used to encrypt all further communications. If private key encryption techniques were used for the transmission of all messages a lot more computational resources would be demanded.

The learner's device is able to identify its location with the aid of a beacon that sends signed messages identifiable by the learner's device when compared to a number of stored signed messages. Thus, we prevent unauthorized transmission or reception from the device, when it resides outside the pre-settled space boundaries.

After authentication has been performed and the session key has been exchanged, all communication can be encrypted end to end from the database to the learner's device using the Secure Sockets Layer (SSL) protocol. When a new request is sent to the database, the policy module is invoked to examine the request, the requester's role and the privileges which have been recorded in the policy. This procedure is supported by most of modern devices, which handle effectively at least 128-bit encryption.

C. System architecture description

The mainstream class in Fig. 2 illustrates the use of the wireless infrastructure offered to D-HH and dyslexic students. You can see two important actors: teacher and teacher assistant. Teachers' multimedia presentations are appeared on the interactive whiteboard and everything written on it can be saved. Assistant can play a key role because s/he communicates (chat based communication) with D-HH students for question-answering, during the lecture. We must mention that the assistant does not know Sign Language (SL).

Another interesting actor is a hearing (volunteer) notes' taker. This role is complementary and s/he takes notes apart from the existence of the interactive whiteboard, which saves presentations and text written by the teacher. You must also notice that between students there are D-HH and dyslexic ones. In order to see presentations, the D-HH students use PDAs or PCs and the dyslexic students use PCs. Dyslexic students have the possibility to adapt user interface according to their preferences and needs. Both students have the option to access more information and multimedia material locally or access other servers out of the classroom. It is assumed that, in the initial stage, they fill forms with personal details (if they want to participate), and documents for the personalized access to the multimedia information and for the adaptation of the interface according to their needs. Privacy of all these personal details is ensured (see Fig. 1).

In Fig. 2, a parallel, "assistive" class is also illustrated. A major difference is that, there is an interpreter in the classroom, which plays a key role. In the parallel class there is neither teaching assistant, nor notes' taker. Hearing volunteers and hearing students are included. Another interesting point is that the presentations and related discussion are recorded for later study. In this case, teaching is based on bilingual presentations. We have also carried out successful experiments to establish communication between the mainstream class and parallel classes, and communication between two parallel classes where there is only one interpreter. The organizational scheme depicted in Fig. 2 can support bilingual teaching, synchronous e-learning and m-learning, and communication. Fig. 2 also illustrates the establishment of a scalable environment including three servers (personalization server, communication server, and database server) and multimedia database of lessons, documents, bibliography. Therefore, the scheme enables asynchronous distance learning and personalized access to distributed databases of educational documents and information. Teacher can exploit this possibility to add material: documents, assignments, small projects, examination tests, results, etc. Personalized services to students are supported through the personalized server and the whole scheme ensures the privacy of the personal details. Data related to the usage of the system (the personalized service) are used to dynamically change user models (profiles).

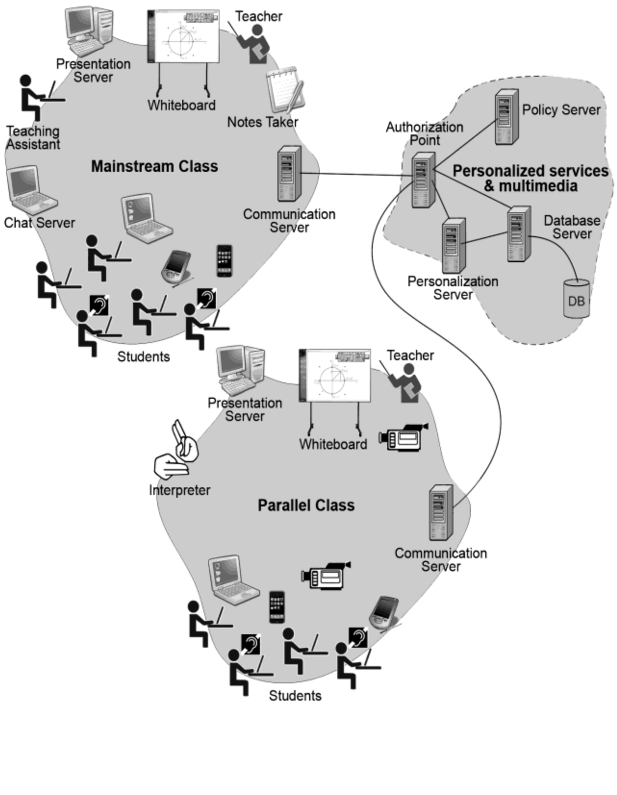

Figure 2. Organizational scheme for supporting teaching and personalized services.

D. The role of servers

In Fig. 2 various servers of multimedia information and data are depicted. These servers were implemented as a part of our research for educational services for dyslexic and D-HH students and support teaching, learning, and personalized access to multimedia information, lessons and documents:

1) Servers of Multimedia Educational and Learning material

A distributed multimedia database of lessons, assignments, small projects, selected bibliography and bibliographic data, grey bibliography and educational material is hosted. Videos in Greek SL are also given.

2) Servers for supporting the inclusion of dyslexic and D-HH students in the mainstream class

During the lecture, dyslexic and D-HH students can access the slides of the teacher's presentation in their PC or PDA, see teacher's notes and also previous slides of the ongoing presentation. D-HH students can watch related video in Greek SL in the case that there is not any interpreter available in the class. Dyslexic students can use earphone to hear the content of the slides and they can modify the user interface according to their preferences and needs.

3) Personalization server

Our experiments mainly include individual users (learners) models. These models are dynamically adaptive to the use of the system. User (learner) models contain personal information about the users, as provided during the registration and information related to their preferences of sources and categories.

III. CONCLUSIONS

In this paper we concerned with the design of adaptive learning environments that enable accessibility for students with disabilities and learning difficulties. We presented the architecture of Secure Wireless Infrastructures and Personalized Educational Learning Environments (SWI_PELE) and the collaboration of these environments. The issue of security is crucial in case of examinations and assignments. Thus, we proposed a secure multi-domain framework which can support various learning environments and infrastructures. Moreover, we described an implemented scheme of servers for educational services. We proposed both the use of blended learning and personalized learning based on parallel classes and servers of multimedia lessons.

In conclusion, wireless networks and PDAs form an attractive and helpful framework for supporting students with disabilities, especially Deaf and Hard of Hearing (D-HH) students, as well as students with learning difficulties, such as dyslexic students.

Of primary interest, for the future, is the further experimentation with stereotypes of Dyslexic, D-HH students for the mainstream class and for accessing educational information and material. Research on various aspects of the user communities of learners is also planned for accessing educational information, material and bibliography.

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