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From the Editors …

Welcome to the October 2010 issue of the Learning Technology newsletter.

Due to the advances in mobile technologies, learning can take place at any time and any place, allowing learners to learn in authentic environments, outside the classroom, through their mobile devices. By using sensors and small computers embedded in learning objects, the current leaning context as well as surrounding learning objects can be identified and considered in order to provide learners with context-based learning experiences by adjusting information, resources and activities to the learners' current context and situation. This issue introduces papers which describe research on pervasive learning and the use of sensors for providing context-based learning experiences as well as present prototype systems and tools that facilitate pervasive learning.

Guo et al. discuss the concept of distributed wisdom (building on crowd wisdom), and outlines a prototype which aims to support lifecycle-oriented learning in a ubiquitous computing context. Malek et al. present a new modelling language and an authoring tool for modelling and generating pervasive, context-aware and adaptive learning scenarios which can be transformed in to IMS LDs. Kaddouci et al. describe a series of prototypes which provide positioning and points of interest (POI) management, and describe how these prototypes are used for investigating different pedagogical scenarios for pervasive learning. Arantes et al. describe the DiGaE CSCL environment together with a use case aiming to illustrate its use in a ubiquitous learning setting. Finally, O'Grady reviews electronic positioning devices and technologies, and discusses their implications for outdoor (and indoor) learning activities which are based on location services.

The issue also includes a section with regular articles (i.e. articles that are not related to the special theme on pervasive learning). In this section, Moebs and McManis describe a study which aimed to investigate the impact of quality of service for multimedia learning.

We sincerely hope that this issue will help in keeping you abreast of the current research and developments in Pervasive Learning and the Usage of Sensors in TEL, as well as advanced learning technologies in general. We also would like to take the opportunity to invite you to contribute your own work on technology enhanced learning (e.g., work in progress, project reports, case studies, and event announcements) in this newsletter, if you are involved in research and/or implementation of any aspect of advanced learning technologies. For more details, please refer to the author guidelines at http://www.ieeetclt.org/content/authors-guidelines.

Deadline for submission of articles: **15 December, 2010**

Special theme of the next issue: **Semantic Web Technologies for Technology Enhanced Learning**

Articles that are not in the area of the special theme are most welcome as well and will be published in the regular article section!

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Special Theme Section: Pervasive Learning and Usage of Sensors in Technology Enhanced Learning

Prompting Lifecycle-Oriented Learning of Ubicomp Applications Leveraging Distributed Wisdom

Ubiquitous computing (ubicomp) is extending the computing domain from desktop computers to sensor-augmented smart objects (e.g., smart furniture, smart cups). By analyzing the sensed intelligence from smart objects, ubicomp applications can sense the ambient context change and adapt their behavior to assist users. Compared to desktop applications, ubicomp applications are more deeply and widely embedded into our daily lives which requires more complex knowledge on user requirement understanding, heterogeneous sensor data processing, application/device administration, and hardware/software failure handling. An application that cannot adapt to its users' needs may simply annoy the user; while complex operations on application behavior control/tailoring will hinder the prevalence of ubicomp applications. Therefore, thinking about a method that can benefit ever-changing user needs while lowering user cost becomes a substantial challenge in ubicomp domain.

The lifecycle of a typical ubicomp application can be divided into three main stages: development stage, distribution stage, and maintenance stage. Existing systems focus merely on the issues involved in one of these stages. For example, a number of toolkits have been developed to allow rapid development of ubicomp applications for developers [1] or end users [2]. Some zero-configuration tools are also built to lower the maintenance cost of end users [3]. There is still no research work addressing the three stages as a whole, let alone the interrelationship among the three stages. For example, the gap between developers and end users on experience sharing has not filled in those studies.

In his book [4], Surowiecki puts forward the concept of "crowd wisdom", which is defined as: "the aggregation of information in groups, resulting in decisions that are often better than could have been made by any single member of the group". Here, crowd wisdom is used for decision making. We are inspired by this definition and extend it to "distributed wisdom" in ubicomp domain. Distributed wisdom has three key elements (see Table 1). The prior two elements emphasize the diversity of various participants and human groups (e.g., professional developers, novice programmers, and average users) in the lifecycle of ubicomp applications. The diversity is reflected in two aspects: wisdom/quality and learning needs, as summarized in Table 2. A deep analysis of the "diversity" in Table 2 reveals the complementarily among people (inter-group and intra-group) on their qualities and learning needs. For example, the application-creation quality of professional developers can generate some application templates for novice programmers' learning, and average-user-ratings to applications can impact other average users on software foraging. The last element − "aggregation", however, indicates the core of our proposal: leveraging the aggregated power of "distributed" wisdom to augment mutual learning and knowledge/experience transfer during the lifecycle of ubicomp applications.

Table 1: Three key elements of distributed wisdom

Criteria	*Description*
Diversity (knowledge distribution)	Each user has their specialized knowledge, skills, and needs
Decentralization	People are able to specialize and draw on local knowledge
Aggregation	There are mechanisms/tools to facilitate knowledge transfer and information sharing among people

Table 2: Distributed wisdom and learning needs over ubicomp user groups

User group	Wisdom/Quality	Learning needs
Sensor makers, Professional developers (High-level)	Sensor knowledge, application creation, programming languages, knowledge on error-handling	Application requirements, Understanding requirements and gathering feedback to improve the system
Novice programmers (Middle-level)	Simple toolkits, modification to open-source software (co-design)	Learn to create applications using examples (sample codes)
Average users (Low-level)	User experience and evaluation (user ratings), problem/requirement owners, rich domain knowledge	Which software to choose? Knowledge on system control/configuration, Error handling method

As shown in Fig. 1, the aggregation of distributed wisdom makes CoLL (our approach) a continuously evolving socio-technical system by (1) providing a set of tools to support different degrees of ubicomp design and use activities, (2) empowering end users to engage co-design activity while not restricting them to existing systems, and (3) promoting knowledge transfer and mutual learning among people. We have developed a prototype platform to demonstrate CoLL (some user interfaces are included in Fig. 2), which empowers lifecycle-oriented learning through a series of activities. For instance, in Fig. 2, User-A from Family-A can "create" a rule-based meta-game (a template with several configurable slots) and then "publish" it to a social website. User-B finds this "high-rating" application through a "foraging" activity, and "co-designs" it in terms of his domestic settings and preferences via a graphical interface (e.g., changing the slot-values in a rule, altering the app-behavior exploring domestic resources). If he has questions (e.g., system failures) and new needs to improve the application, he can "contact" the developer for help. If he finds it an interesting game, he can "recommend" it to his friends. A semantic sensing infrastructure has been explored to develop the prototype, and some programming activities have been tested in our past study [5]. We extend it to the whole lifecycle of ubicomp apps and propose a unified approach to formulate it.

To conclude, we believe that the aggregation of distributed wisdom can bridge the cognitive gap between developers and users in ubicomp domain, and promote knowledge transfer and mutual learning among them. We will do further experiments to quantitatively measure the performance of the CoLL approach.

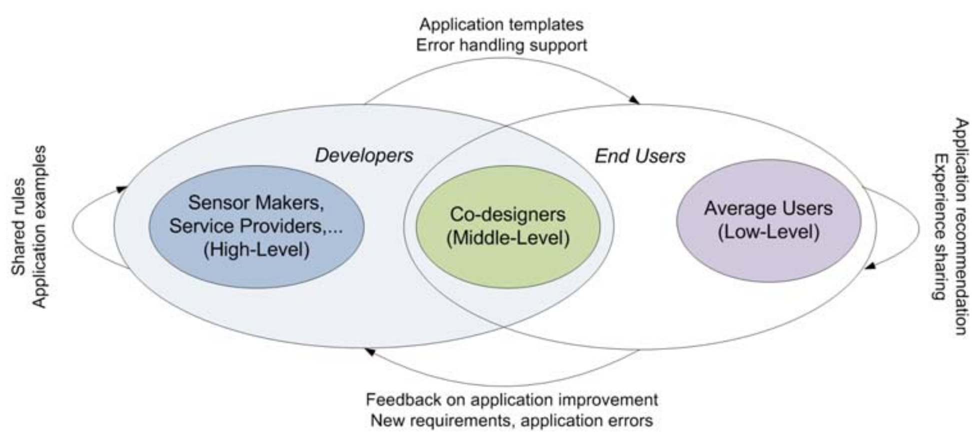

Fig. 1. The collaborative lifecycle-oriented learning (CoLL) approach for ubicomp applications.

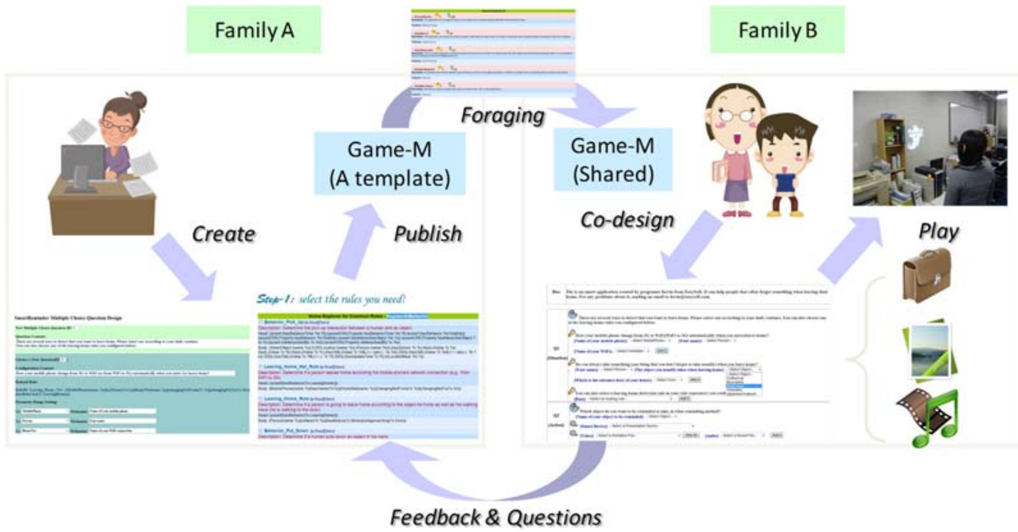

Fig. 2. A game scenario for CoLL.

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An Approach for Modelling Pervasive Learning Scenarios

This paper presents the results of our innovative approach that aims at supporting pedagogical designers and teachers to model, generate and simulate pervasive, context-aware and adaptive learning scenarios. Its core element consists of an Educational Modelling Language called CAAML (Context-aware Adaptive Activities Modeling Language). An authoring tool called ContAct-Me was developed based on CAAML language.

Introduction

Several studies claim advantages of using wireless, mobile and pervasive technologies to enhance learning processes [1], but a review of existing Educational Modeling languages and their authoring tools shows that none of them supports pervasive learning related concepts when dealing with the modeling of learning activities [2]. From then on, we propose a model-driven approach that supports pedagogical designers and teachers to model, generate and simulate innovative context-aware adaptive and pervasive learning scenarios and activities. This can have a pedagogical added value to learning processes and not only be a mobile version of existing e-learning activities. As a matter of fact, this new learning philosophy ensures learner's autonomy, motivation and challenge by experimenting with various learning scenarios indoors and outdoors. Additionally, it helps to improve interaction and collaboration through collaborative and challenging learning activities taking place in different locations and various stages.

In order to apply and test this approach, an authoring tool called ContAct-Me (**CONT**ext and **ACT**ivity Adaptive Modeler for **M**alleable Learning **E**nvironments) has been created. It transforms models represented in CAAML language into models represented in IMS-LD standard to ensure interoperability of the designed activities across different learning platforms. ContAct-Me is based on CAAML (Context-aware Adaptive Activities Modeling Language) language that takes into account the concepts of context and co-adaptivity defined in previous works [3] [4].

CAAML: A Visual Educational Modeling Language for Pervasive Learning

In this section, we present the CAAML language through a description of its meta-model. To define its elements, we based our approach on the activity theory, a philosophical framework used to conceptualize human activities [5]. There are two main reasons for using activity theory. On one hand, it provides a simple and standard form for describing human activity. On the other hand, it takes into account the concepts of tool, community, rules and division of labour, which are important in a Context-aware collaborative learning environment (cf. Figure 1). The CAAML meta-model describes a learning scenario as being a composition of several phases. Each phase includes role-parts (activities and their relevant contexts) as shown in Figure 2. The context can be:

- Static: does not change during interaction (e.g., season, student's name);
- Dynamic: changes during the interaction (e.g., noise level, temperature…). A dynamic contextual element can be directly acquired through "Embedded environmental sensors" or "mobile device sensors".

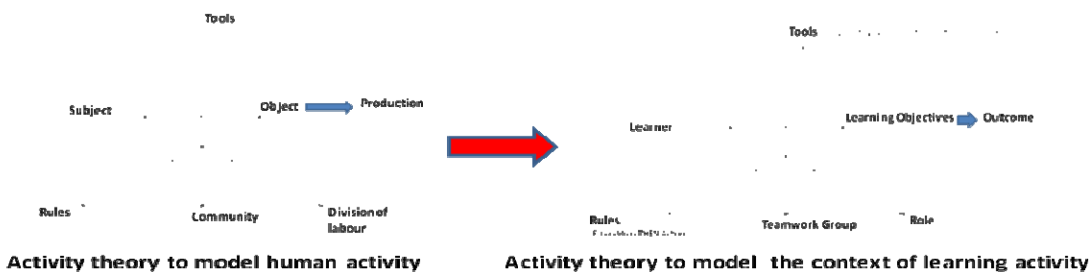

Figure 1. Applying Activity Theory for Pervasive Learning

In the previous work [3], we proposed an innovative approach based on co-adaptivity or bijective adaptation between context and learning activities within pervasive learning environments. Indeed, the CAAML Meta-model defines two classes of “co-adaptivity rules”: rules for adaptivity of context to activity and others for activity to context. A rule is based on a context to trigger the adequate co-adaptivity’s actions.

The CAAML Meta-model defines also components related to pervasive learning environments such as “Smart objects”, “Sensors” and “Mobile or pervasive services”.

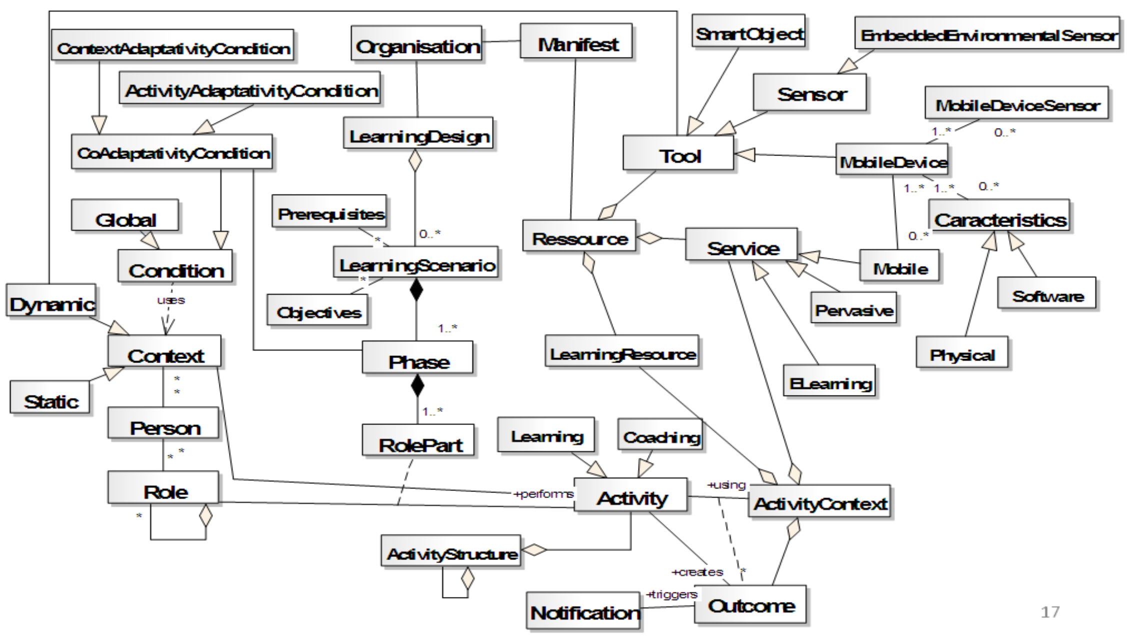

Figure 2 The CAAML Meta-model

ContAct-Me Architecture

ContAct-Me is an authoring tool based on CAAML language through an MDD approach (Model-driven development). It aims at supporting pedagogical designers to model and simulate context-aware adaptive learning scenarios using friendly interfaces.

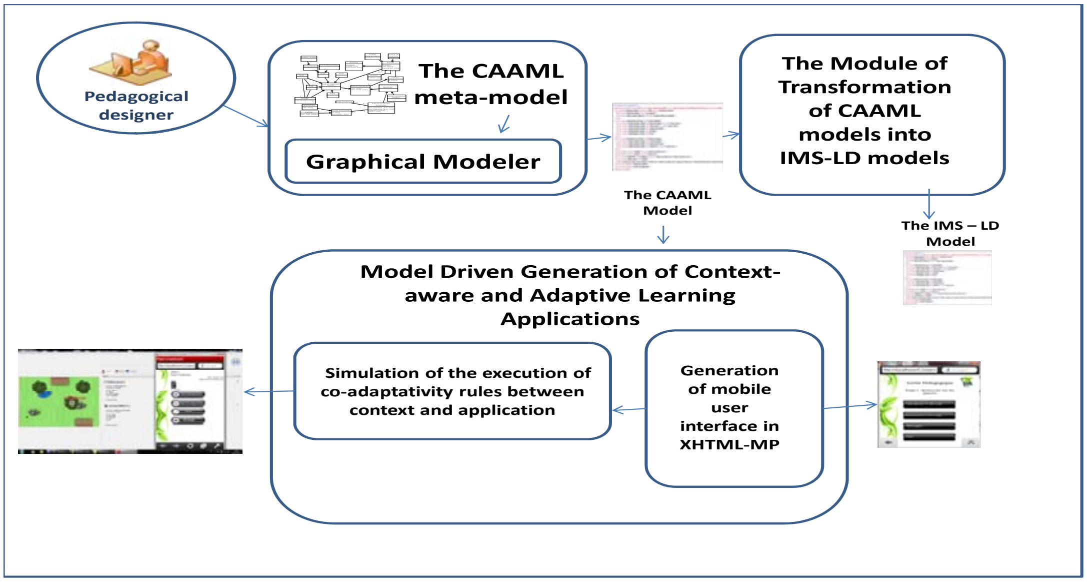

Figure 3. ContAct-Me Architecture

The architecture of ContAct-Me includes three interrelated Modules (as shown in Figure 3):

The graphical Modeler: Through this module, the pedagogical designer can:

- Model context-aware activities;
- Define pervasive learning environment components and resources (mobile devices, smart objects, sensors, mobile services...);
- Model Co-adaptivity rules.

The CAAML/IMS-LD models transformation module: In order to ensure interoperability of the designed activities across different learning platforms, this module transforms models represented in CAAML language into executable models represented in IMS-LD. This is done in a way the IMS-LD complexity is hidden by the use of concepts related to context-awareness.

The Simulator of pervasive learning scenarios module: This module allows:

- The CAAML model-driven generation of mobile user interfaces;
- The simulation of the execution of the scenario in run time (execution of co-adaptivity between the context and the application).

Conclusion

ContAct-Me is an authoring tool based on CAAML language, which is an Educational Modeling Language that aims at supporting pedagogical designers to model, generate and simulate innovative context-aware, adaptive and pervasive learning scenarios.

We tested and evaluated the proposed approach by pedagogical designers who has appreciated modeling scenarios with friendly graphical interfaces and the automatic generation of mobile interfaces as well as the simulation of the modeled scenario, which shows interactions between pervasive environment and the application.

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Coupling Pedagogical Scenarios and Location-based Services for Learning

Introduction

Pedagogical scenarios popularized by the IMS-LD standard offer a way to describe the learning activities and their organization. This language is both a means to elaborate and share pedagogical design and a support for the execution within Learning Management Systems (Peter el al., 2007). However, with the progress of technology for wireless networks and sensors, the mobile devices are becoming a link between the physical space and the digital one. Hence, they have become a learning tool which permits authentic and situated activities (Traxler, 2009). Mobile learning activities can be spontaneous and context-driven or based on a careful design of the learning space (either at the physical (Rogers et al., 2004) or at the digital level (Facer et al., 2004)). In this research work, we want to see the benefit of using pedagogical scenarios for the design of the mobile learning activities and how location-based services, can support the learning activities.

Scenario and user interfaces

We have developed prototypes which provide positioning and points of interest (POI) management and that associate a set of activities to the POIs based on a pedagogical scenario execution engine (Peter et al., 2007). The prototypes user interfaces are developed on top of the Android platform and tested on HTC smartphones. The interaction with the physical world relies on two mechanisms:

- The phone GPS supports positioning of the user and POIs.
- The camera is used to scan QR codes. This provides both a way to locate precisely the user and a trigger to access data and activities linked to the place.

We have two alternative prototypes for the experimentation. One is based on Google maps which shows the position of the user and the POIs so s/he can go from one point to the other. The other one relies on the Augmented Reality browser Wikitude (Wikitude) (see Figure 1) which enable the user to see POIs on top of the camera view. A third application is used to scan QR codes and to retrieve activities for the current location (see Figure 2).

These prototypes are used in a scenario to discover the university campus for new students. Usually the university services available to the students (health care, job & traineeships search…) are presented during an introductory speech at the beginning of the year and a booklet is given to them. However, students do not give full attention to this, rather long, presentation. Based on that, we have defined a route visiting the main services. At each service, they have to find information (see Figure 2) by asking people or looking at the available documentation. The order of the activities (and hence the route) is defined in a workflow based language. QR code scanning triggers the scheduling of the activities.

Figure 1 - Wikitude augmented reality interface

Figure 2 - Location related activities to perform

System architecture

Our system is composed of three main elements:

- The pedagogical scenario engine provides available activities for a user according to the scenario (Peter et al., 2007).
- The task manager instantiates the scenario for a user and keeps track of the user context while interacting with the scenario engine.
- The user application runs on the Android smartphone. Upon scanning a QR code, it will retrieve tasks from the manager.

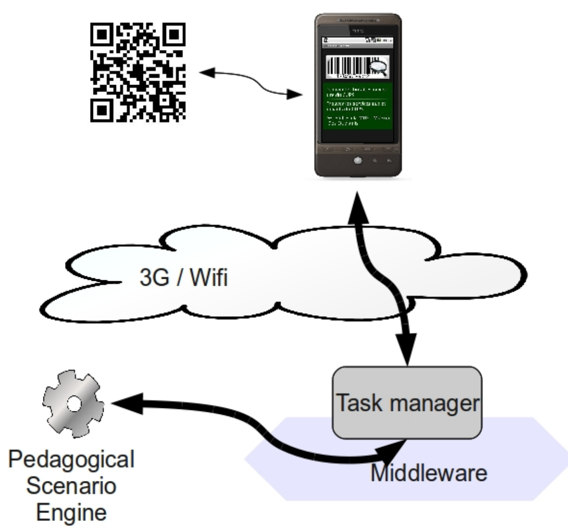

Figure 3 - Components of the prototypes

User evaluation and outlook

For the evaluation, we use the task manager to support the scenario and three modalities to help navigation around the campus: using a paper map, using Google map and using Wikitude. The last two modalities will help us show the usefulness of the navigation applications and we will be able to compare the friendliness of the two interfaces for the task of finding POIs and navigating from one to another. Each user passes a questionnaire prior to the experiment and a questionnaire after the activity so that we can evaluate the familiarity with the technologies, the current practices, the user interfaces, the design of the activities as well as their knowledge of the university campus. We are just beginning the trials with 2 students using Google maps and 2 students using Wikitude so it is far too early to draw any conclusion. The students were quite used to touch interfaces and tools like Google maps so it was not difficult for them to use the prototypes. They would mainly have problems due to inconsistent GPS positioning at some times which is not something we can improve. Otherwise, they were positive about the scenario as a guidance to discover the campus and its services. However, we observed that the task to fulfill should be more precise and that we should plan a summary activity at the end based on information collected at each place. This is because the students who did the experiment, gained a good knowledge of the campus geography but their memory of details of the services offered was not so good. These first observations will be completed during the experiment and we will refine the scenario according to the results.

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Using Sensors as an Alternative to Start-up Lectures in Ubiquitous Environments

Introduction

Technology can support various forms of collaborative teaching and learning activities [1]. The *DiGaE (Distributed Gathering Environment)* is a software tool which, when associated with instrumented environments, allows users to participate in distributed meetings. Given that *DiGaE* supports collaborative meetings, one of its main use-cases scenarios is related to learning activities. *DiGaE* combines a set of tools designed to support learning activities in synchronous sessions: the Whiteboard, Conference and Chat tools. Considering the several alternatives for using an instrumented environment with several tools, it is important to offer alternatives not only for configuring a given synchronous session but also for starting up the session --- *DiGaE* employs a session concept for the former [2], and RFID sensors for the latter.

DiGaE-Room and DiGaE-Home

In order to provide communication support during a distributed lecture, a *DiGaE-Room* environment is equipped with a video camera, an audio capturing system, an electronic whiteboard, and a RFID reader. A teacher uses the *DiGaE session tool* to prepare a *DiGaE session* in advance so as to configure the use of other software tools allowing the exchange and capture of audio and video (*Conference tool*), the exchange of slides and pen-based interaction (*Whiteboard tool*), and the exchange of text (*Chat tool*). The *DiGaE session tool* also allows the identification of the participants and of the meeting (e.g. title, description and start and ending times). The information exchanged during a session is captured and used to automatically generate automatically multimedia documents for review.

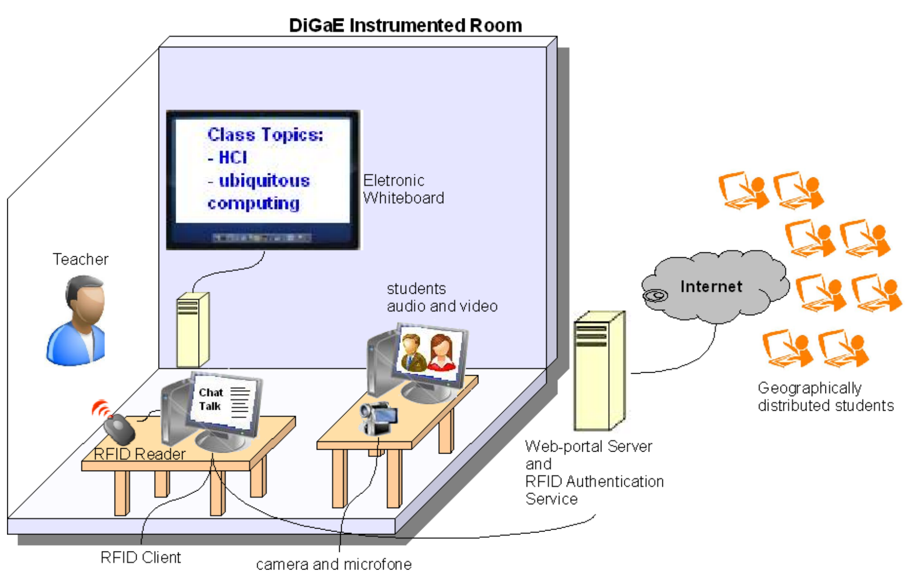

Figure 1 – DiGaE instrumented room with local teacher and remote students.

One of the uses of the *DiGaE-Room* in an e-learning scenario is illustrated in Figure 1. The teacher is located in a *DiGaE* instrumented room, and the students are located in a remote environment. The environment is instrumented with an RFID reader, an electronic whiteboard, a camera and a TV set. The teacher interacts with remote students using applications which start up automatically once she touches the RFID reader with the identification card. Applications which may start up automatically include the Whiteboard tool, the Chat tool, and the Conference tool. Remote students participate in the lecture using the *DiGaE-Home tool,* shown in Figure 2.

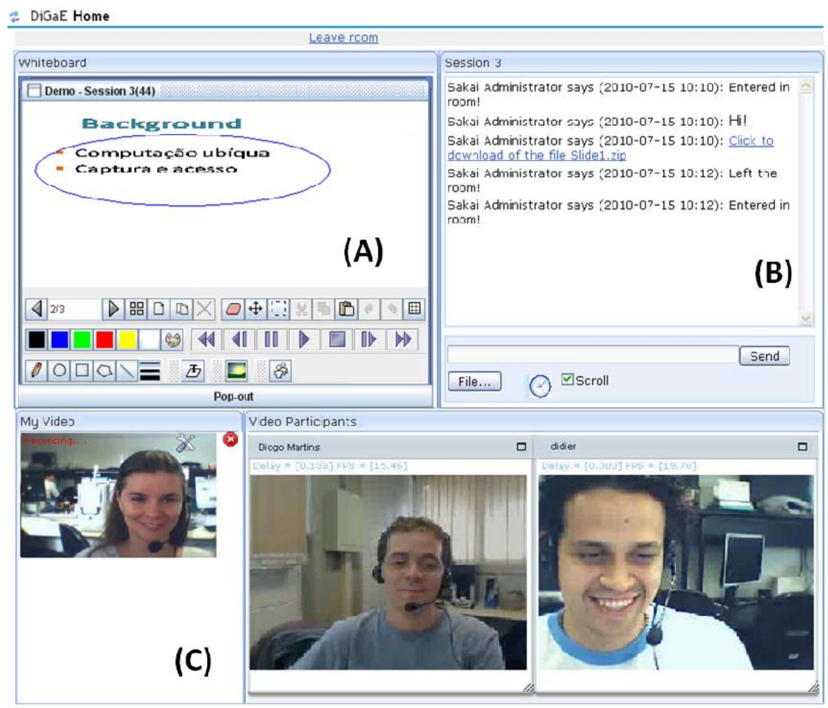

Figure 2 –Remote students using *DiGaE-Home* tool with *Whiteboard tool*, text-based *Chat tool* and videoconferencing *Conference tool*.

Web-based start up

The *DiGaE tools* run in a web portal[1] built on top of the Sakai[2] framework. To use any tool available in the web portal, teachers and students have first to provide their identification and password. Once logged in, they gain access to a (different) worksite for each course they are involved in. Each worksite is configured with a set of tools selected by the teacher (e.g. the Chat, Wiki and Calendar tools). To access a given tool in the context of a specific course, users select the worksite corresponding to the course and activate the chosen tool.

In order to start up an environment as the one depicted in Figure 1 using a web portal, the teacher would need to log in the several computers associated with the many tools (e.g., one computer for each Whiteboard, Chat, video and audio Conference tools) before each lecture. Similarly, each remote student would have to log in and start up each tool separately.

Sensor-based startup

To support the scenario presented in Figure 1, the computers in the *DiGaE Room* run a set of software agents which control the automatic startup of each software tool in the appropriate machine. As a result, to start a lecture a teacher has to (a) schedule the class with the *DiGaE Session tool* [2], (b) enter the *DiGaE* instrumented room and (c) swipe her RFID card in the

[1] http://tidia-ae.usp.br/portal
[2] http://sakaiproject.org

reader. As a result, all configured tools are automatically started in their corresponding machines, and the *DiGaE Room* environment is ready for the lecture.

Shortcut-based startup

In order to enter the *DiGaE-Home tool* as illustrated Figure 2, we provide users with the following alternative: by using the *DiGaE-Session tool* they can create a *DiGaE personal shortcut*. This demands the users to provide their login information (with an extra password) and to download a software shortcut on the desktop of the computer used to participate in the lecture. To enter a lecture students execute their personal shortcut (clicking in the shortcut and providing the extra password): as a result, the student is automatically placed in the lecture scheduled for that time of the day using the set of software tools selected by the teacher.

Conclusion

Our aim in building the several *DiGaE tools* was to facilitate the use of distributed environments by teachers and students. In a distributed class, users usually enter a web portal in a predefined date and time, provide their login and password, remember in which workspace they should enter, and possibly which tool or tools to use. With *DiGaE*, the teacher only has to schedule the lecture providing some configuration information [2]. As a result, session-based applications can use that configuration information to take several actions, such as to automatically log users in the lecture.

In this article, we have shown scenarios in which ubiquitous computing facilitates that teachers and students participate in distributed lectures. We have used this infrastructure in several meetings involving remote peers.

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Location Awareness for Pervasive Learning

Electronic aids for navigation represent one of the success stories of consumer electronics in recent years. Sensors for determining location have been integrated into a range of products from automobiles to watches, and a range of services have been developed that harness such sensors. Thus, educators now have an unparallel opportunity to facilitate students move outside their classrooms and laboratories, thereby enabling learning to take place in a range of alternative but relevant situations. However, depending on the discipline in question, a broad understanding of issues relating to location accuracy is necessary if full advantage is to be gained from the proliferation of electronic positioning devices on the market.

Introduction

Many disciplines demand extracurricular work that invariably takes place outside the classroom. In many cases, this occurs under the guise of field work, and usually involves groups of students and their mentors visiting some geographic location where issues raised in class can be illustrated in a relevant environment. This approach has stood the test of time, and is consistent with experiential [1] and situated learning [2]. However, by equipping students with cheap navigation devices, responsibility for learning can be transferred to the student in many instances, allowing them conduct field work on their own initiative. Most students are equipped with mobile phones, many of which are augmented with a position-sensing mechanism, and include a selection of software packages that can take advantage of position. To gain a deeper understanding of positioning, two key categories are now considered - satellite and terrestrial.

Satellite Systems

Satellites are the key enabling technology for most of the navigation services available at present [3]. The Global Positioning System (GPS) is predominant, and most of the position sensors available on the market use this technology. A position accuracy of 20 meters or greater may be expected, on average. This is sufficient for many purposes but in some circumstances, greater accuracy may be needed. In this case, Satellite Based Augmentation Systems (SBAS) may be harnessed. Examples include the Wide Area Augmentation System (WAAS) in North America and the European Ground Navigation Overlay Service (EGNOS) in Europe. Both of these augment GPS resulting in a position accuracy of approximately 5 meters.

From a learning perspective, learning situations that require accurate positioning of the student demand the use of GPS, ideally augmented with an SBAS technology. Consider the case of a field study in geology, for example. Broad characteristics of a rock formation may be visible, or indeed only appreciated, when a certain distance from the rock outcrop itself. Thus a standard GPS position should be adequate. However, in cases where the instructor wishes to focus student attention on some minute aspect that will only be visible when physically in its immediate vicinity, GPS augmented with an SBAS will be required. A key issue here is that the student can go the point of interest with a minimum of difficulty. Thus it beholds the instructor to explicitly visit the area in question, and consider it from a student perspective, and in terms of the preferred positioning technology. The scenario outlined here is applicable in a number of disciples.

Terrestrial Systems

A range of techniques for determining location using terrestrial wireless technologies [4] are in operation. The most common, however, have been deployed by cellular network operators in response to regulations concerning emergency call management. One popular technique, Cell-ID, involves associating a subscriber with the Base Station that routes their calls. The radius of the area served by the Base Station will determine position accuracy. A key difficulty with techniques based on cellular network technologies is that the accuracy varies, and this variation cannot be quantified by the subscriber. This has significant implications when being harnessed in mobile learning scenarios. However, the difficulties are not insurmountable if the limitations are understood, and the learning issues in question are tolerant of a relatively large positional error. In the study of physical geography, it may be desired to direct students' attention to large scale features or select features of a landscape. Obviously, a large scale object can be observed from a large distance and from a variety of viewpoints, although some may be preferable from an instructional view point. However, the scale of the objects under investigation will frequently disguise the inherent error position of the technique being harnessed. Thus learning is not compromised.

A Note on Indoor Scenarios

Though field work is usually synonymous with the outdoors, this need not always be the case. However, all the techniques described previously will not operate satisfactory in indoor environments due to interference with signals. A number of dedicated solutions for indoor environments exist, for example, Ubisense [5]. However, these are rarely deployed, primarily due to expense. Museums and art galleries are obvious places of learning, but technologies for guiding visitors are rarely deployed. Thus conventional approaches must be adopted, and given the relatively small scale nature of buildings, this is not a major problem and should not hinder learning.

Concluding Remarks

Cheap navigation, tracking and positioning systems are now commonplace. This development offers training professionals an unprecedented opportunity to incorporate mobile learning strategies into their curricula. Where the subject matter allows it, instructors can encourage and easily facilitate learning in environments where students should obtain a greater benefit and understanding of the topic under consideration.

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Regular Articles Section

From Delphi to Simulations: How Network Conditions Affect Learning

Introduction

Web-based e-learning is not only supplementing traditional classroom teaching, but also providing educational access to diverse populations in potentially remote locations that in the past would not have been reachable. Despite these benefits, there are well-identified issues with student retention due to lack of social interaction and difficulties encountered by students when interacting with the technological medium [1]. To compensate for these difficulties there is an imperative to make the course material as attractive as possible, an effort which frequently equates to providing media-rich content. However, this material places a greater demand on network resources possibly leading to Network Quality of Service (QoS) problems and in turn student frustration with the delivery of material.

In the e-learning sphere, QoS concerns have in the past either been ignored or resulted in the use of only the least demanding resources. If the differences in network quality are ignored, multimedia e-learning can get very tedious. Every resource with slightly higher demands on network resources will be burdened with long start-up delays. If on the other hand e-learning utilizes only the least demanding resources, usually a combination of text and images, the missing mix of different media can negatively affect the motivation of the learner [2]. Considering the challenge of student retention in e-learning, both approaches must be seen as problematic.

We present expert opinion on the impact of QoS in e-learning as garnered from a Delphi study surveying experts in the field of multimedia e-learning and contrast this with the findings of a simulation study looking at the impact of QoS for a number of typical e-learning scenarios. In this context we postulate that the QoS has a strong impact on the student experience in e-learning. Considering that it is widely accepted that any improvement in speed of connection is compensated by an even bigger increase in demand [3], this impact is likely to continue despite the ever-increasing delivery capabilities of the network.

Delphi Study

The Delphi study involved 25 international experts in a three-round online-study. Participants showed their level of agreement with a list of 17 hypotheses [4] and ranked them according to importance. The hypotheses concerned the impact of the use of multimedia on learning and flow experience [5] and the impact of QoS on learning and flow experience. In this paper, we consider how the experts view the impact of multimedia and QoS on learning.

Network Simulations

The simulations were done with the NS-2 network simulator [6]. An application model was built which represents the behavior of a multimedia e-learning application. The simulations consider two media mix (MM) profiles for a dial-up as well as a DSL2 connection. The profiles are characterized by percentages for the different types of media (see Table 1) typically found in e-learning scenarios.

Table 1: Media Mix Profiles

	Text+images	Audio	Video
MM1	80%	10%	10%
MM 2	40%	30%	30%

MM1 represents a traditional profile, consisting mainly of text and images, resulting in lower demands on bandwidth. MM2 includes a higher percentage of audio and video and therefore has higher demands on bandwidth.

From Delphi Results to Simulations

We consider three of the 17 hypotheses related to the desirability of multimedia in e-learning and the impact of QoS on learning (see Table 2). As we can see from HA, there was a high level of agreement that multimedia improved learning, and further that it was an important factor (ranking 5 out of 17). HB and HC were the two hypotheses concerning the impact of QoS on learning. These were two of the three lowest ranked hypotheses in the Delphi study. They also exhibited a high degree of controversy with HB having a significant minority disagreeing, and opinion being relatively evenly split for HC.

Table 2: Selected Results from the Delphi Study

	Final Rank	**Hypothesis**	**Percentage** Agreement / No opinion / Disagreement
HA	5	Learning materials providing a mix of different media lead to improved learning results.	84% / 8% / 8%
HB	15	Using selected still images rather than streaming video can increase learning if the auditory narration quality of the original video is maintained.	68% / 8% / 24%
HC	17	A clear increase of the resolution of videos and images leads to increase of learning.	20% / 36% / 44%

So, the experts remain unconvinced about the role of QoS in e-learning. Perhaps the following simple simulations results might change their mind. The simulation results show significant start-up delays for both profiles and the different network conditions (see Figure 4). Start-up delays are lowest for DSL2 and MM1 – the least demanding profile and the connection with the most generous bandwidth conditions. Nevertheless MM1/DSL2 shows start-up delays of up to 50 sec, depending on the number of sessions. And even though DSL2 can accommodate bandwidth demands much better than the dial-up connection, start-up delays begin at 50 sec for MM2 and can go up to almost 140 sec.

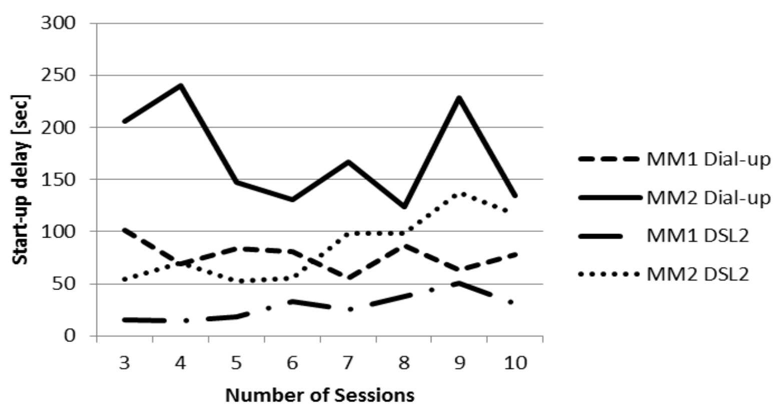

Figure 4: Simulation Results

Conclusions

The results of the Delphi study show that experts consider a mix of media highly relevant for learning while they do not consider network conditions of much importance. The simulations indicate that this view is perhaps short-sighted. Simulations with multimedia e-learning profiles exhibit considerable start-up delays, which eventually affect the e-learning experience [7].

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Book Announcement

Web 2.0-Based E-Learning: Applying Social Informatics for Tertiary Teaching

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Educational communities today are rapidly increasing their interest in Web 2.0 and e-learning advancements for the enhancement of teaching practices. Web 2.0-Based E-Learning: Applying Social Informatics for Tertiary Teaching provides a useful and valuable reference to the latest advances in the area of educational technology and e-learning, with an emphasis on the use of social software tools such as blogs, wikis, podcasts, and social networking sites for teaching, learning, and assessment. This innovative book offers an excellent resource for any practitioner, researcher, or academician with an interest in the use of the Web for providing meaningful learning experiences.

Table of Contents

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