Jornadas de Seguimiento de Proyectos, 2007
Programa Nacional de Tecnologías Informáticas

U-CAT: Ubiquitous Collaborative Adaptive Training
TIN2004-03140

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Abstract

The goal of the U-CAT project is the development of an integrated environment for the realization of educational activities through the use of different devices (personal computers, laptops, mobile phones and PDAs) in different contexts and situations. The aim is to adapt activities, tools and contents to the current context and the available devices, taking advantage of the possibilities offered by the use of ubiquitous computing to do both individual and collaborative teaching activities.

The U-CAT research group has formerly worked on adaptive hypermedia systems, collaborative learning, active environments and virtual laboratories. This work, which has given rise to several systems and tools, has been used as the starting point in the design and implementation of the U-CAT environment. With the aim of validating and checking the effectiveness of this adaptive environment, several teaching activities are being performed within it, in the Escuela Politécnica Superior of the Universidad Autónoma de Madrid (UAM). Classrooms and labs are being used as scenarios for the proposed activities, complementing both traditional lectures and practical work.

Keywords: intelligent environments, adaptive hypermedia systems, collaborative learning, context adaptation, quality evaluation, e-learning, mobile and ubiquitous computing, computer supported cooperative work / learning, network management

1 Project Goals

The U-CAT[*] project continues work from several prior projects, some examples are ENSENADA (TIC2001-0685-C02) focused on adaptive learning tools and environments, or INTERACT (TIC2000-0464), with emphasis on ambient intelligence, and several others (see project proposal). The goal of the project is the integration of recent technologies in the fields of Intelligent Environments, Ubiquitous Systems, Adaptive Hypermedia Systems, and Computer Supported Collaborative Work in the context of higher education. This implies

- An extension of the concept of adaptive learning systems to take into account "context" in the sense of so-called "ambient intelligence" systems.
- The application of Adaptive Hypermedia and CSCW user/group models and adaptation frameworks to problems present in traditional intelligent environments.

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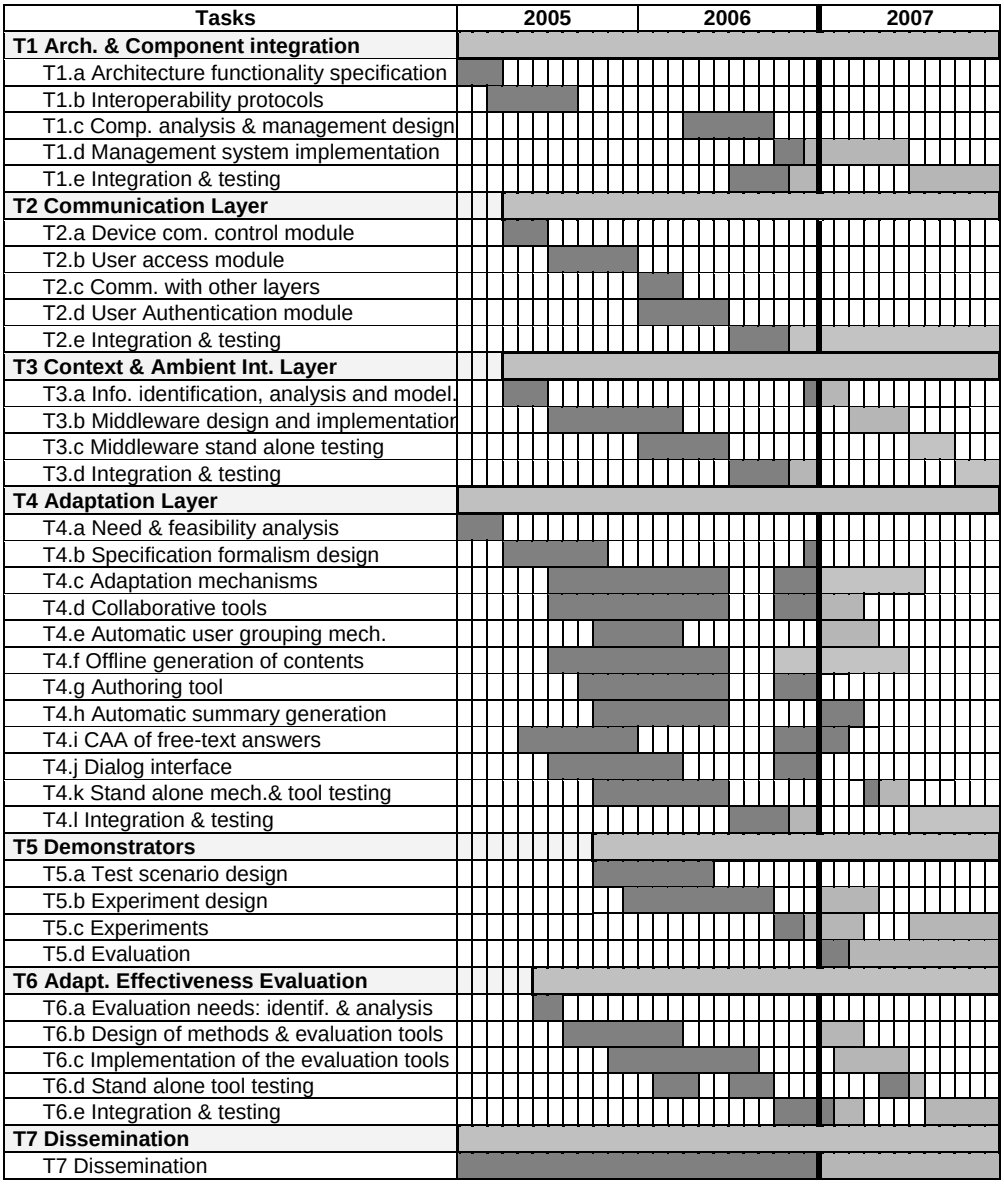
[*] IN MEMORIAM Javier Martínez. He worked hard on the U-CAT proposal and made it possible, but could not enjoy it.

- The design of scenarios within a higher education setting that can be used to experiment with the proposed integration and analysis of the results in an effort to determine general guidelines.

To achieve these goals, seven tasks were proposed, organized in the following chronogram.



Given the high degree of uncertainty considering how the integration of these technologies would work out, the project's duration was divided into two incremental development cycles. After an

initial three-month period of architectural design, the development would start on all tasks, leading to a first system in month 18. This would include preliminary versions of all tests and scenarios, so that a round of experiments with the system could be performed.

The second development cycle would focus on tasks T3 (context and ambient intelligence) and T4 (adaptation), which would be revised to take into account the results gathered from the first cycle. This would lead, at the end of month 30, to a revised version of T3 and T4. The project's last 6 months will cover a final round of integration, including all tests, to measure both the degree of success and the effectiveness of the second cycle. Regardless of the end-of cycle tests, research and experiments with scenarios are being performed continuously throughout the project.

2 Task review and indicators

In general, the development of mechanisms and tools are well within schedule, and some of them started even earlier than planned. However, the integration of the whole system is advancing slower than expected. This is mainly due to the fact that the implementation of the proposed demonstrator is largely dependant on the technology available to the students. Even although the technology and devices required for some demonstrators are already available at the market, their high prices prevent a wider adoption of them by the students. For that reason, some experiments were simplified to fit the available technology, while others were downsized in order to use only devices owned by the research group.

Therefore, task T1 is only partially fulfilled and slightly behind schedule. The first phase of this task finished with a meeting with all the project participants at a workshop held in Granada at the CEDI'05 conference. During this phase, a common architecture was designed and interoperability protocols were agreed upon. The development of the different mechanisms and tools follows these architectural guidelines. Some of these tools have been tested independently and integrated with others. The integration and testing of the complete system are still pending.

With respect to T2, it follows the schedule as planned. The system capabilities regarding this layer will be specifically tested in an experiment to be carried out in February, as explained below (T5).

Regarding task T3, the middleware layer has been implemented and the benchmarking of the platform has already been performed. The following step is the integration with the rest of developments.

Concerning the adaptation layer (task T4), the analysis of the adaptation needs and feasibility was already done (T4.a). During this task execution, we decided to leave it open in case that new needs were detected. Currently we consider this task as finished. We have also finished both the specification of the adaptation formalism (T4.b) and the development of the corresponding adaptation mechanisms (T4.c), which could be refined in the following months, if needed. Regarding task T4.d, a collaborative tool to design and deliver educational materials has been developed. With respect to task T4.e, we have carried out one experiment dealing with the detection of grouping criteria, and are currently carrying out a more complete one (task T5.c). The results obtained feed the mechanism for automatic user grouping already developed, which could be improved in the case that new needs are detected after the next experiments, as it was foreseen

in this task. Concerning tasks T4.g, T4.h, T4.i and T4.j, all of them started before it was planned and have already been finished. In contrast, task T4.f was postponed because the offline tool does not need to be integrated with the rest of the system and its development would be easier after the main components of the adaptive layer are implemented. Finally, each mechanism and tool implemented has been tested independently (T4.k), and new ones will be checked accordingly.
Demonstrators are being developed (T5), as it was explained above, with some difficulties. Demonstrators testing the whole system functionality have not been implemented yet. However, some experiments to test individual developments and partial integrations have already been carried out:

- Three different experiments were carried out with high-school students and teachers, testing both the advantages of introducing Adaptive Educational Hypermedia (AEH) technology for supporting attention to diversity, and the tools to support AEH authoring (T4.g).
- A large experiment was conducted with more than 160 university students to investigate the impact of learning styles on the way in which students group themselves and also on the results of the collaboration tasks performed by them. The results obtained feed the mechanism for automatic user grouping developed (T4.e).

Other experiments are currently being carried out, associated to tasks T4.e (student grouping) and T4.i (CAA of free-text answers). Also, some other experiments are scheduled during the next two months aimed at:

- Testing of the adaptation mechanisms developed in task T4.c, which supports context-based activity recommendations for students.
- Testing the use of mobile phones for supporting student participation in large groups (more than 100 students). This experience will take place within our traditional classrooms The integration of the software developed in T2 and T4 will be used.

Finally, activities of task T6 have followed the planned evolution. Particularly, the integration of the evaluation methods and tools with the adaptive layer, as well as its testing, are even more developed than was originally intended. The main reason is the development of a simulation tool to generate synthetic logs. In this way, it was possible to test how evaluation tools would analyze and provide feedback to the adaptation layer even before this layer were developed. The main pending activity of this task is to apply the evaluation tools to the student data (to be obtained from the experiments mentioned above).

The research carried out during the project has given rise to relevant scientific and technological results, such as four doctoral thesis and the publications enumerated in the next section.

3 Project Results

3.1 Research Staff

The members of the research groups that carry out this project come from two Spanish universities: U. Autónoma de Madrid (UAM) and U. de Granada (UGR). Besides, other three researchers coming from two European universities are also taking part in U-CAT. The Ph.D. researchers initially involved in the UAM group were: X. Alamán, E. Alfonseca, R.M. Carro, F. Gómez, S. Holgado, J. López de Vergara R. Moriyón, A.Ortigosa and P. Rodríguez. In UGr, the

participants are M.Gea, J.L.Garrido and R. López-Cózar. Also, since the beginning of this project, G. Montoro, P. Haya and M. Mora have been working on dynamic dialogs in ambient intelligence, collaborative analysis of the learning process and context information in ambient intelligence, respectively, in the framework of the project. They all defended their doctoral thesis and got their PhD degrees in 2005-2006. Moreover, M. Freire, P. Paredes and D. Pérez are expected to defend their PhD thesis in 2007. Their works centers in complex graph-based structure visualization, learning styles and adaptive computer assisted assessment of free-text answers, respectively. Also, J.A.S. Itmazi defended his Ph.D. Thesis in 2005 at UGr in the U-CAT framework, dealing with e-learning in open and traditional universities.

Finally, other 9 Ph. D. students have already got their research qualification (DEA) at UAM and UGr within the U-CAT project framework..

3.2 Publications

Work on this project has given rise to 14 publications in international journals [1-14] and 39 presentations and publications in international and national conferences [15-53] (see section 4).

3.3 Technological Transfer

The design of the "DeepTest" computer application (2005), transferred to Active Documents S.L, is a direct result of technological transfer from our research lines. This application focuses on the resolution of exercises based on interactive documents. Other companies that stand to benefit from technological transfer are Ikerland and Coloplast S.A., which are closely following project results for their employee training needs.

A professorship sponsoring agreement has been reached with "Soluziona Consultoría and Tecnología S.L.", a leading IT consulting company. The "Cátedra de Patrocinio UAM-Soluziona CyT de Inteligencia Ambiental, Seguridad y Privacidad" will fund a full professorship in the area of ambient intelligence environments, focusing on security and privacy aspects, at UAM.

3.4 Participation in International Projects

Project researchers are participating in two relevant Integrated European Projects, AceMedia and COST 278. AceMedia is centered on the development and use of "Autonomous Content Entities" that would contain and identify semantically any type of multimedia contents. The project seeks to generate such entities automatically using advanced knowledge extraction and classification techniques, and enable advanced processing of these entities through knowledge-based techniques.

The "Spoken Language Interaction in Telecommunication" project, supported by the European Commission as COST 278, seeks to develop spoken language support, dialog management and multimodal communication for distributed systems. Support for pronunciation variants and multilingual speakers are other important research lines in this project.

3.5 Collaboration with Other International and National Groups

As already mentioned, three researchers from two European universities also take part in U-CAT project: J. Schlichter, chair of the "Group XI: Applied Informatics - Cooperative Systems" of the Department of Informatics of the Technical University of Munich (TUM), and S. Garlatti and Y.

Kemarrek, from the Department of Artificial Intelligence and Cognitive Sciences, *Ecole Nationale Supérieure des Télécommunications de Bretagne* (ENST), France. Both J. Schlichter and S. Garlatti regularly visit our group in Spain, as well as members of our group visit their research centers (M. Freire in June 2006, J. Bravo since April 2007 to June 2007).

Additional relations have been established, among others, with the ITC-irst research centre in Trento (Italy), where D. Pérez spent 5 months (Aug. 2004-Dec. 2004); University of Texas (USA); Tokyo Institute of Technology Precision, were E.Alfonseca spent one an a half year (Jul. 2005-Dec. 2006); and University of Lancaster, where M.A. Mora is spending one year (Feb. 2007 – Jan. 2008). These relations are giving raise to other possibilities of collaboration in the context of the U-CAT project, as well as to joint publications.

Also, U-CAT researchers keep relationships with other Spanish groups that share the same interest, such as the LIPNE group at UPV/EUH (Laboratorio de Interacción Persona-Computador para Necesidades Especiales) or the CHICO group (UCLM).

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