

# ERCIM NEWS

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Special:

## Technology-Enhanced Learning

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**Next issue:**

*January 2008  
Special theme: The Future Web*

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*Cover illustration by Dorel Gorga ([dorel\\_gorga@bluewin.ch](mailto:dorel_gorga@bluewin.ch)).*

## Technology-Enhanced Learning: Supporting Learning in the 21st Century

Technology-enhanced learning may not flow readily off the tongue or be easily translated as a brand name, but it very consciously reflects what it is: using ICT to secure advancements in learning. By taking advancements as the objective, we go beyond the attempt to reproduce classical ways of teaching via technologies. Technology-enhanced learning combines but places equal emphasis on all three elements – on technologies, on learning and on enhancements or improvements in learning. This will help us in devising ICT-based solutions which motivate and inspire learners and teachers, engaging them in meaningful learning and teaching experiences.

The European Commission, in the framework of its ICT research programmes, is supporting technology-enhanced learning. The context for this research continues to be shaped by a number of trends – economic and educational policy-related. First, in the workplace, learning technologies are becoming an integrated and critical component of business processes, corporate knowledge management and human resource systems. If learning can be delivered seamlessly, providing knowledge without interruption to people's normal work and if time-to-competence can be reduced, then organisations can better show return on investment in the learning systems. In this context, greater emphasis is placed on informal and organisational learning.

The second noticeable trend is on the individualisation of learning, ie the tailoring of pedagogy, curriculum and learning support to meet the needs and aspirations of individual learners, irrespective of ability, culture or social status. This is accompanied by the shift to assessing learning outcomes and doing this not at set ages but according to the progress and needs of the individual. Technologically, the focus has moved from sequencing of content to sequencing learning activities and pedagogical scenarios.

The focus on the individual is giving new prominence to engagement and creativity. Here a number of different technologies are creating opportunities for supporting motivation and empowerment of the learner. Recently, there has been a dramatic increase of interest in game-based learning or "serious games". These games have defined learning outcomes, and exploit video-game principles, such as self-pacing, built-in remediation, assessment and motivation, for education and training. Immersive environments, advances in narratives, virtual characters and storytelling are suggesting new ways to generate affective engagement and improving attention span. Visualisation, simulations and virtual experimentation enable learners to explore problem spaces in new ways. IT and creativity – with cognitive models/processes inspiring computational models/processes – is an emerging trend in both education and industry, supporting innovation and problem solving.



*Pat Manson*

*European Commission, Head of Unit  
Cultural Heritage & Technology Enhanced Learning  
Directorate General Information Society and Media*

"Technology-enhanced learning" was coined to identify what the researchers working on ICTs and education saw as a new perspective. Some six years ago, research results were helping to push the mainstreaming of e-learning in the form of learning management systems, remote access to electronic resources and courseware through virtual campuses and brokerages, and training and simulations for the workplace. The interests of research shifted then towards looking at the learning process and the learner, at understanding the interactions between learner and systems, between groups of learners, and between learners and teachers/mentors. This was enabled by newer technologies that better supported participation and interactivity. The focus was less on integration of technological components but rather on understanding learner behaviour in using the systems to learn.

Today we can move forward. We can look at how (or if) the appropriate use of the technologies results in improvements in learning – making it more effective, and more efficient. However, if technology-enhanced learning is to be successful as a new model for research and for learning, then there are a number of challenges for the research and educational communities. First, the emphasis on learning as the driver means that any approach must be multidisciplinary, involving not only different strands of technological research but also pedagogy, psychology and cognitive sciences extending into neuroscience. Secondly, if technology-enhanced learning is defined as a factor for improvement, then we need to be able to demonstrate where and how improvements take place.

If technology is to enhance learning for the 21st century, it is critical that research builds a convincing scientific body of evidence as to which approach works and under which circumstances. From there, we can create showcases and exemplars of what works, demonstrating how individuals are supported in learning and in developing competencies throughout life.

*Pat Manson*



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# CLeMUS - Computational Learning Methods for Unsupervised Segmentation

by Emanuele Salerno and Simon Wilson

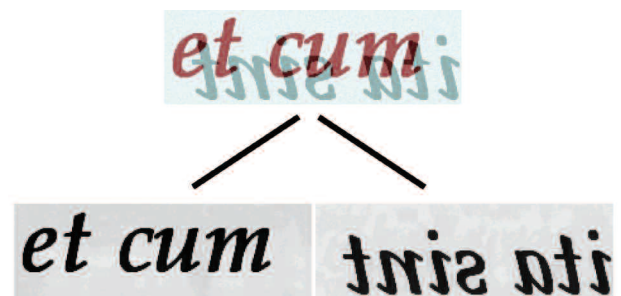
*An invited session on computational learning methods for unsupervised segmentation was held on 14 September in the framework of the 11th International Conference on Knowledge-Based and Intelligent Information & Engineering Systems (KES 2007) in Vietri sul Mare, Italy. This initiative was taken by the MUSCLE 'e-team' on unsupervised segmentation and classification of multichannel data. MUSCLE (Multimedia Understanding through Semantics, Computation and Learning) is a European Network of Excellence managed by ERCIM.*

Many measurement procedures are intended to extract information on physical systems by exploiting spectral diversity. This implies that the system components must be identifiable from their emission spectra. The different imaged components – that is, the different classes in the data images – are not necessarily spatially separated: more than one component may exist in a single resolution cell. This leads to generalized notions of 'segmentation' and 'classification', where the aim is not to partition an image such that each region is assigned to a single class but, for example, to assign to each class a percentage occupation in each resolution cell. This problem may be further complicated when the spectral features of the individual classes are not known a priori, leading to the need for blind processing. Similar problems can arise with other 'multichannel' data sets that involve multiple points of view, time delays, polarizations etc, rather than frequency diversity. This leads to a generalized notion of 'channel', including any possible kind of diversity exploited to form a multidimensional data set. This is an important task for multimedia techniques and as such, is a central topic for MUSCLE.

The scope of this kind of analysis is being widened continuously, well beyond the original concerns of multispectral and hyperspectral data analysis. Among the applications for which this type of approach has recently been proposed are astrophysical image processing, remote-sensed image analysis, digital analysis of documents and artworks, medical and industrial diagnostics and computational biology. Several approaches have been used in attempts to solve these problems, often relying on statistics to overcome the lack of specific information. Among the solution techniques we find component and factor analysis, generalized Kalman filtering, particle filtering, Monte Carlo Markov chains and other Bayesian approaches. The activity of the MUSCLE e-team on unsupervised segmentation and classification deals with all these topics, with particular reference to Monte Carlo techniques and astrophysical imagery. The participants are from the "Alessandro Faedo" Institute of Information Science and Technologies of CNR in Pisa, Italy, and from Trin-

ity College, Dublin. The aim of the CLeMUS session was to encourage the cross-fertilization of ideas coming from the different application areas.

All these considerations have been confirmed in light of the contributions that were received. There were five presentations from the fields of remote sensing, astrophysical imaging, blind source separation and deconvolution, and medical image processing. Very diverse approaches were adopted, such as Bayesian MAP estimation, the use of statistical measures on the observed data, mathematical morphology and multiresolution classification. However, within this variety of methods several commonalities can be observed, which encourages us to pursue further initiatives similar to CLeMUS in the hope that adopting a common viewpoint to study these problems will help us to develop new and unified theoretical and technical tools to solve them. Apart from the common use of diversity data, we find that a popular attitude towards unsupervised tasks, especially when no known data model is assumed, is to rely on statistics and, in particular, on statistical features such as independence, decorrelation or



*Unsupervised classification of overlapped patterns from an RGB color data image.*

Gaussianity. Two contributions made specific reference to the spatial structure of the class images, through either a Markov random field model or a nontrivial spatial autocorrelation. The extended notion of classification mentioned above was adopted in three contributions, while the other two assumed spatially separated segments. In studying the details more closely, many other common points would be found. Interested readers will find the papers published in Volume 4694 of the Springer Lecture Notes in Artificial Intelligence series.

## Links:

<http://www.muscle-noe.org>

<http://kes2007.kesinternational.org>

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## Cor Baayen Award 2007 for Boris Motik

*Boris Motik from University of Oxford, United Kingdom, has been awarded the 2007 Cor Baayen Award for a most promising young researcher in computer science and applied mathematics by ERCIM.*

In a tight competition with 17 finalists, ERCIM has awarded Boris Motik for the outstanding quality of his work concerning reasoning algorithms and systems for Description Logics (DLs) - a family of knowledge representation formalisms with applications in numerous areas of computer science. DLs provide the basis for the Web Ontology Language (OWL) - the ontology language defined by the World Wide Web Consortium (W3C) that has become the de facto standard for ontology development in fields as diverse as geography, geology, astronomy, agriculture and the life sciences. Boris has already made wide ranging contributions to research, including both new theoretical results, and practical systems that promise to change our notion of tractability in ontology reasoning.

Boris's output is impressive: in spite of the fact that he only completed his PhD in 2006, he has already published more than 40 articles in leading international conferences and journals, and won the best paper prize at the 2005 International Semantic Web Conference (ISWC 2005) for his paper "On the Properties of Metamodeling in OWL".

Boris studied for his Bachelor's and Master's degrees at the Faculty of Electrical Engineering and Computing at University of Zagreb, Croatia, where he received the faculty award Josip Lončar for the best student of the generation. Boris's PhD work at Technical University Karlsruhe, Germany, broke new ground in scalable reasoning for ontology languages. Boris showed that the data complexity (i.e., the complexity measured in the size of data only) of ontology reasoning is lower than the combined complexity (i.e., the complexity measured in the size of data and the ontology) of reasoning. This shows that there are no fundamental limitations to scalability of reasoning in data intensive application -- that is, in applications where the size of the data dominates the size of the ontology. He also developed a completely new DL reasoning technique based on a reduction to disjunctive datalog. Unlike the existing techniques, this new technique

exhibits worst-case optimal complexity, and it also enables the reuse of established optimisation techniques, such as magic sets, that greatly improve performance of reasoning with large amounts of data.

Boris's contributions were not only theoretical: he implemented a new reasoning system (KAON2) based on his reasoning algorithms and demonstrated that, on relatively simple ontologies with large data sets, the new system can answer queries several orders of magnitude faster than existing tableau based implementations. This work is of great importance to the future of the Semantic Web and ontology language applications more generally, where an inability to deal with large volumes of data has been a serious impediment to wider adoption. This is illustrated by the fact that Boris's work is already the basis for a commercial ontology management system being marketed by ontoprise GmbH.

In addition to his work on KAON2, Boris has made several other important research contributions. In his work on meta-modelling, he showed that the basic reasoning problems become undecidable if certain features of the Resource Description Framework (RDF) are combined with more expressive languages such as OWL, and that decidability can be restored by restricting the use of syntax reflection. This is an important result as it shows that it is possible for ontology languages to support meta-modelling while still retaining decidability, thus addressing the requirements of many Semantic Web applications. Boris's work on combining the best features of the Description Logic and Logic Programming paradigms has also been highly influential. He also worked on bridging the gap between description logics and relational databases, and proposed a framework for the integration of the open-world semantics of the former and the closed-world semantics of the latter formalism. Finally, he developed a novel calculus for DL reasoning based on hypertableau, and implemented it in a new reasoning system HermiT. This system was the first one to process certain large life-science terminologies, thus solving some long-standing open problems in scalability of reasoning with large terminologies.

### Finalists 2007

According to the award rules, each institute was allowed to select up to two finalists from its country. The ERCIM institutes have nominated the following 17 finalists for the 2007 Cor Baayen Award: Marcin Bienkowski, Poland; Yves Bontemp, Belgium; Nick Cook, United Kingdom; Henri Dubois-Ferriere, Switzerland; Felix Klaedtke, Germany; Nikos Komodakis, Greece; Levente Kovacs, Hungary; Dániel Marx, Hungary; Boris Motik, United Kingdom; Guillaume Perrin, France; Srikumar Ramalingam, France; Andrey Rybalchenko, Germany; Panu Korpipää, Finland; Magnus Sahlgren, Sweden; Risto Sarvas, Finland; Elias Tsigaridas, Greece; Danny Weyns, Belgium.

### Link:

<http://www.ercim.org/activity/cor-baayen.html>

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## 14th Workshop of the ERCIM Working Group Environmental Modelling

by Thomas Lux

*The 14th workshop of the ERCIM Working Group Environmental Modelling was held on 3-4 September 2007 at Aristotle University of Thessaloniki, Greece.*

Members of the Working Group (WG) participated along with researchers from the Informatics Application and System Group and of other departments of the Thessaloniki University in order to present their recent research work and to discuss the current trends and developments in the field of environmental modelling.

Research issues that have been addressed in the workshop presentations included:

- modern methods of knowledge extraction from huge environmental data sets (computational intelligence, data fusion),
- modeling and simulation tools as well as communication and presentation means for the citizen for operational air quality forecast on all the scales from European to street canyon level,
- simulation and modelling, in particular using interactive Grid technology, in coastal and river research (Tsunami, floods) and other life science domains.

The group discussed plans for further topics and ways of collaboration, including the exploration of bilateral funding sources as well as the perspectives of joint European proposals.

The group decided to support the organisation of a session at the next International Congress on Environmental Modelling and Software (iEMSS2008 <http://www.iemss.org/iemss2008/>) in Barcelona, Spain, with the topic 'Environmental modelling applications towards quality of life information services'.

The meeting was organized by the new member of the working group - Professor Kostas Karatzas and his group from the Aristotle University Thessaloniki.

During the workshop Professor Achim Sydow announced his retirement from the chairman position of the ERCIM WG Environmental Modelling as which he acted since the foundation of the group in October 1996. He proposed his colleague Dr. Steffen Unger from Fraunhofer FIRST as new chairman. The proposal was confirmed by the WG members.

### Link:

<http://ercim.first.fhg.de/>

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### CALL FOR PAPERS

## CSCLP 2008: Annual ERCIM Workshop on Constraint Solving and Constraint Logic Programming

Rome, Italy, 18-20, 2008

The workshop, which is also the 13<sup>th</sup> meeting of the ERCIM Working Group on Constraints, will cover all aspects of constraint and logic programming, including foundational issues, implementation techniques, new applications as well as teaching issues. Particular emphasis is on assessing the current state of the art and identifying future directions. Authors are invited to submit papers on all aspects of research on constraint and logic programming. Standard research papers, position papers and work-in-progress papers describing current projects are all welcome. To submit a paper to the workshop, please prepare a postscript or pdf file, preferably in Springer LNCS format. Papers can be of any length but should not exceed 15 pages. All submissions must be received by 11th April 2008.

**More information:** <http://pst.istc.cnr.it/CSCLP08/>

## ERCIM Working Group on Soft Computing Draws to an End

by Petr Hajek

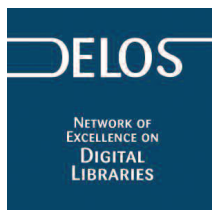
The sixth workshop of the ERCIM Working Group on Soft Computing, held on 11-14 September in Ostrava, Czech Republic jointly with the EUSFLAT 2007 conference (see <http://www.eusflat2007.cz/>) was the last workshop of the ERCIM Working Group. The group decided to cease its activity because a shift of interest had taken place. The group members plan to apply for a new ERCIM Working Group in the near future with the provisional title 'Mathematical Fuzzy Logic'.

The proceedings of the previous fifth workshop will be published under the title 'Foundations of Soft Computing' with a subtitle as "Selected papers from the Fifth Intl. Conference The Logic of Soft Computing and the Workshop of the ERCIM Working Group on Soft Computing".

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## Second DELOS Conference on Digital Libraries

Pisa, Italy, 5-7 December 2007

*After four years of activities, DELOS, the Network of Excellence on Digital Libraries, funded by the European Union under the Sixth Framework Program and managed by ERCIM, will demonstrate the major results achieved by the members of the network at the Second DELOS Conference on Digital Libraries in Pisa on 5-7 December 2007.*

Digital Libraries represent the meeting point of a large number of technical areas within the field of informatics, ie, data management, information retrieval, document management, information systems, the web, image processing, artificial intelligence, human-computer interaction, mass-storage systems, and others. Moreover, Digital Libraries draw upon several other disciplines and fields beyond informatics, such as library sciences, museum sciences, archives, sociology, psychology, etc. In addition to providing substantial contribution to research in many of those fields, DELOS has also been successful in establishing a large European research community on this multi-faceted research field, and it is hoped that this community will continue in the future most of the main activities of DELOS, regardless of possible funding from the European Union.

The activities of DELOS, in a broad meaning, started many years ago, with the "ERCIM DELOS Working Group" at the end of the nineties, and the DELOS Thematic Network, under the Fifth Framework Program, from 2001 to 2003. Since the beginning, the main objective of DELOS has always been that of advancing the state of the art in the field of Digital Libraries, by coordinating the efforts of the major European research teams carrying on activities in the technology fields of interest to Digital Libraries.

The second DELOS conference will last two and half days. The first two days will be dedicated to presentations by members of the DELOS community of their latest research results and their main contributions in those research areas where they have focussed their activities in the last few years. On the last half-day tools and services implemented as prototypes of varying degrees of completeness will be presented. Actually, the implementation of a Digital Library Management System embodying most of the results produced by DELOS Community members is one of the main efforts on which DELOS has been focussing in the last period.

On December 4th, the day before the start of the conference, two satellite events are planned. The first one is a one-day workshop on the Digital Library Reference Model defined by DELOS, where the results of the first stage of the project will be presented. By their very nature, Digital Libraries are served by a research community that has been historically heterogeneous and involves scientists from a large number

of disciplines. This workshop will be the fourth in a series aiming at bringing together the international Digital Library community, especially researchers interested in Digital Library modelling and working on the foundations of the field, for intensive brainstorming and exchange of ideas. The series of workshops also intends to serve as a vehicle for expanding the set of researchers involved in the formation of the Reference Model, starting from those actually participating in the workshops, and continuing on afterwards through appropriate collaborative instruments initiated by DELOS.

The second event planned to be held in the afternoon of December 4th is a special session on Multilingual/Multimedia Access to Cultural Heritage, where the latest results of MultiMatch will be presented. MultiMatch is a spin-off project of DELOS and CLEF, which aims at providing personalized information access to digital objects in the Cultural Heritage Domain. The project addresses issues of interoperability at three levels: language, content, and media. The solutions adopted will be discussed and the prototype search engine will be demonstrated.

### DELOS Research Areas

#### Foundational Research

- Reference Model for Digital Library Systems

#### Systems-Related Research

- Digital Library System Architectures
- Information Access to Digital Libraries
- Audio/Visual Digital Libraries
- Semantic Interoperability in Digital Libraries

#### User-Related Research

- User Interfaces for Digital Libraries
- Digital Library Visualization
- Personalization in Digital Libraries

#### Horizontal Issues

- Digital Library Curation and Preservation
- Digital Repositories
- Digital Library Evaluation Methodologies
- Digital Library Evaluation Infrastructures

The whole event is intended to provide also a forum for discussion and exchange of ideas. Anyone interested in organizing special sessions on specific topics, before or after the conference, is invited to get in touch with the conference secretariat with their proposals. It is planned to organize a special session with some of the projects with which DELOS is cooperating (eg DILIGENT, DRIVER, MICHAEL, TEL, etc) to discuss ways and possibilities of continuing the cooperation at the end of the funding period.

#### More information:

<http://www.delos.info/ConferenceII/>



## Policy on the Web

W3C is pleased to announce the launch of the Policy Languages Interest Group (PLING) which is chartered to discuss interoperability, requirements and related needs for integrating and computing the results when different policy languages used together, for example, OASIS XACML (eXtensible Access Control Markup Language), IETF Common Policy, and P3P (W3C Platform for Privacy Preferences). This group is part of the Privacy Activity and its work follows up on the W3C Workshop on Languages for Privacy Policy Negotiation and Semantics-Driven Enforcement, held last year. Participation is open to W3C Members and the public.

### Links:

<http://www.w3.org/Policy/pling/>

<http://www.w3.org/2006/07/privacy-ws/report>

## W3C to Work in "Video on the Web"

The past few years have seen an increase in the availability of video content on the World Wide Web and the demand for such content will keep increasing dramatically. Consumers want more content to be made available, in higher quality, and to take full advantage in their living rooms of high definition television. The video industry (television and cable networks, content producers, content delivery systems, etc.) is looking at ways to be ahead of the demand and be on top of the next wave of innovations in the domain. Several factors could slow down the increase, such as lack of interoperability, unsearchable or inaccessible content, or digital rights.

W3C will be looking at the impact and challenges of video on the Web in the upcoming months. With widespread video technologies, what do we expect the next Web application to look like? A workshop, to be announced shortly, will be W3C's next step to gather interest.

## Distributed Web Applications Workshop Report

The report of the Workshop on Declarative Models of Distributed Web Applications is available. The report recommends that W3C create requirements for declarative modeling of Web applications, and a gap analysis that identifies where existing standards are insufficient. The Workshop was hosted in Dublin by MobileAware with the support of the Irish State Development Agency, Enterprise Ireland.

### Link:

<http://www.w3.org/2007/02/dmdwa-ws/report.html>

## Successful W3C/OpenAjax Alliance Workshop

The Workshop on Mobile Ajax, co-sponsored by the W3C and OpenAjax Alliance, was held on 28 September 2007 in Mountain View, California. The chairs were Daniel Appelquist of Vodafone, co-chair of the W3C Mobile Web Initiative (MWI) Best Practices Working Group, and Jon Ferraiolo of IBM, representing OpenAjax Alliance.

The workshop was designed to provide a forum for participants to exchange information about the present state of Mobile Ajax, share visions for its possible future, and identify opportunities for industry collaboration in order to promote end-user and industry success with Mobile Ajax. Representatives from thirty-six separate organizations attended the workshop.

A summary of the discussions and next steps for work are available in the workshop report. The report recommends support of existing standards activities rather than starting new standards activities. Among areas the Workshop identified as needing attention are JavaScript access to device APIs, offline/disconnected operation, widgets, mashups, and security.

### Links:

<http://www.w3.org/2007/06/mobile-ajax/report.html>



## Mobile Web Initiative at MobileMonday London

Entitled 'The Mobile Web revisited', the 8 October 07 Mobile Monday event was hosted by the W3C Mobile Web Initiative, with support from the European IST project 3GWeb.

Through a series of talks and demos, the event explored the current state of the Mobile Web. Things have changed over the past year, with the standards for mobile maturing, real business models emerging, and not least a passionate debate about the role and place of transcoding and adaptation in helping mobile users enjoy an experience of Web sites that were not designed with mobile in mind.

Philipp Hoschka, Deputy Director of the W3C, as one of the speakers, presented on how the standards landscape has developed to support people who wish to present a customized mobile user experience.

### Links:

<http://mobilemonday.org.uk/>

<http://www.w3.org/Mobile>

<http://www.w3.org/2006/3GWeb/>

## W3C Completes Bridge between HTML/Microformats and Semantic Web

The World Wide Web Consortium completed an important link between Semantic Web and microformats communities. With 'Gleaning Resource Descriptions from Dialects of Languages', or GRDDL (pronounced "griddle"), software can automatically extract information from structured Web pages to make it part of the Semantic Web. Those accustomed to expressing structured data with microformats in XHTML can thus increase the value of their existing data by porting it to the Semantic Web, at very low cost.

"Sometimes one line of code can make a world of difference," said Tim Berners-Lee, W3C Director. "Just as stylesheets make Web pages more readable to people, GRDDL makes Web pages, microformat tags, XML documents, and data more readable to Semantic Web applications, opening more data to new possibilities and creative reuse."

One aspect of recent developments some people call 'Web 2.0' involves applications based on combining — in 'mashups' — various types of data that are spread all around on the Web. A number of active communities innovating on the Web are sharing data such as calendar information, contact information, etc. These communities have developed diverse social practices and technologies that satisfy their particular needs. For instance, search engines have had great success using statistical methods while people who share photos have found it useful to tag their photos manually with short text labels. Much of this work can be captured via "microformats". Microformats refer to sets of simple, open data formats built upon existing and widely adopted standards, including HTML, CSS and XML.

GRDDL is the bridge for turning data expressed in an XML format (such as XHTML) into Semantic Web data. With GRDDL, authors transform the data they wish to share into a format that can be used and transformed again for more rigorous applications.

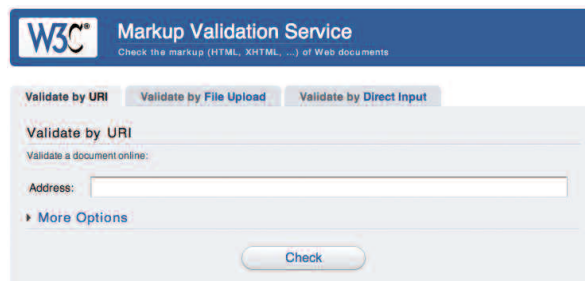
The Working group has produced GRDDL use cases that provide insight into why this is useful through a number of real-world scenarios, including scheduling a meeting, comparing information from various retailers before making a purchase, and extracting information from wikis to facilitate e-learning. Once data is part of the Semantic Web, it can be merged with other data (for example, from a relational database, similarly exposed to the Semantic Web) for queries, inferences, and conversion to other formats. The Working Group has also produced a GRDDL service that allows users to input a GRDDL'd file and extract the important data.

### Links:

<http://www.w3.org/TR/2007/REC-grddl-20070911/>  
<http://www.w3.org/TR/grddl-scenarios/>  
<http://www.w3.org/2007/08/grddl/>

## New W3C Markup Validator Unveiled

W3C's most popular service just got better, prettier, faster, and smarter. The W3C Markup Validator has a new user interface and a validation engine with improved accuracy and performance. Among new features are an automatic



*New markup validator interface.*

cleanup option using HTML Tidy, and checking of HTML fragments. Driven by W3C as an open-source software project, the markup validator is made by Web professionals for Web professionals, and aims to be a major step in any Web development quality process.

### Link:

<http://validator.w3.org/>

## Latest W3C Recommendations

- Gleaning Resource Descriptions from Dialects of Languages (GRDDL)  
11 September 2007, Dan Connolly
- GRDDL Test Cases  
11 September 2007, Chimezie Ogbuji
- Web Services Addressing 1.0 - Metadata  
4 September 2007, Ümit Yalçınalp, Marc Hadley, Tony Rogers, Martin Gudgin
- Web Services Policy 1.5 - Framework  
4 September 2007, Frederick Hirsch, Maryann Hondo, David Orchard, Toufic Boubez, Prasad Yendluri, Ümit Yalçınalp, Asir S Vedamuthu
- Web Services Policy 1.5 - Attachment  
4 September 2007, Frederick Hirsch, Maryann Hondo, Prasad Yendluri, David Orchard, Toufic Boubez, Ümit Yalçınalp, Asir S Vedamuthu
- Semantic Annotations for WSDL and XML Schema  
28 August 2007, Holger Lausen, Joel Farrell

### Link:

<http://www.w3.org/TR/>

# Technology-Enhanced Learning

by Peter Scott and Christine Vanoirbeek

*Initially known as ‘computer-assisted learning’ and later e-learning, the study of improving learning processes by the use of technology has evolved into the research domain known as ‘Technology-Enhanced Learning’. Its objective is to encourage the emergence of new learning models that are sustained by the context-aware use of technology and anchored in the practices of users.*

Technology-Enhanced Learning (TEL) has a long and chequered history. Indeed, since we started to use technology such as paper and chalk we have been seeking to enhance the student’s experience and to make learning easier or more effective (these being not necessarily the same thing, of course). The computer, and then the Internet, have changed many things in the modern world: our learners carry clever and expensive mobile computer devices (phones, laptops, PDAs); they can immerse themselves in complex social gaming worlds (typically to virtually shoot each other); the vast libraries of the world are now at their fingertips; and some of these resources can now be constructed by the learners themselves, rather than only passively consumed.

In the late 1960s, the newly invented computer was harnessed for the service of learners. In 1972 the Control Data Corporation released PLATO IV, a significant, and excellent, predecessor of all subsequent computer-assisted learning systems. With the advent of the microprocessor and the personal computer we saw micro-PLATO in 1980, offering the vision of ‘programmed learning’ to the new generation. Learners could pull up a course on their terminal, which would fill with carefully designed screens of material, and just as carefully designed interactions for them. For some critics, much of modern pedagogy and the technology in which it is embedded has failed to move beyond the models of forty years ago. Where the behaviourist models of systems like PLATO were exciting and visionary for their time, some modern systems do not seem to have moved far from

those original models. “Elearning,” as Eisenstadt (2007) notes, “conjures up dreary images of ‘sitting in front of a computer screen’ while ‘studying’ some ‘content’, which (with a few exceptions) is a pretty awful way to learn.” [Eisenstadt, M. (2007) Does Elearning Have To Be So Awful? (Time to Mashup or Shutup). Proceedings of the IEEE 7th International Conference on Advanced Learning Technologies, Niigata, Japan, 18-20 July].

The challenge for 21st-century TEL then, is to demonstrate to the critic how far we have come since those early online courses, with pages of book learning turned into simple and effective drills for learners. In this ERCIM News special theme we have sought to collate some of the best ideas flowing out of European research institutes, and to show how our research is rising to this challenge and making some great pedagogical leaps.

The four themes which emerge in this issue are very much in line with the expectations of our learners, as noted above. With computing now being mobile and heading towards some level of ubiquity, research in TEL is responding with a range of mobile applications, and especially over hybrid networks and environments. An interesting specialist field in the mobility/ubiquity topic is that of a future world in which many objects use or are identified by computer chips. Radio Frequency Identification tags (RFID) offer the simplest concept of a tagged world. Once we can identify objects in the world (including ourselves), the power of ‘context awareness’ to provide useful extra learning data becomes very interesting, as do the dangers and challenges related to the security of and permissions for such data.

In some of the other work presented here, the topic of mobility joins with the second theme of ‘gaming’. The potential power of immersive 3D gaming environments is reflected in a few contributions to this issue. The topic of games has a good history in TEL research since the work of visionaries like Thomas



Malone in the mid-70s and early 80s put the spotlight on motivational factors in learning technology [Malone, T.W. (1981) What makes computer games fun? Byte, 6, 258-277 (Reprinted in Computers in Education, 1982, 4, 14-21)]. The modern games-and-learning researcher has been working on multiplayer immersive environments for some while now, and the development of an internet business around the virtual 3D world of 'Second Life' (Linden Research Inc, 2007) has given this thread of research a significant boost. Both in immersing mobile devices in virtual worlds, or taking them out into the world to have motivating interactions with it, exciting potential leaps are being made beyond the simple pedagogy of our past.

The third scheme reflects on the vast libraries of information that learners can now access. It seeks to provide structure for these learning repositories, and to help learners navigate and teachers create effective new materials. One of the most exciting and innovative movements reflected here is that of Open Educational Resources (OER). The OER researchers are seeking to make learning resources, previously locked into universities, open to the world and accessible in powerful and interactive architectures.

These architectural issues lead to the final theme in these papers, commonly described in so-called Web 2.0 language as empowering learners to take control of the process: to reflect, create and communicate. This includes tracking their learning experiences in ePortfolios, collaboratively working together in groups, and even 'argumentative collaboration' in specialist systems that can help them frame and visualize learning discussions.

The papers selected in this edition illustrate the benefits that multidisciplinary research can bring to the design and adoption of new 'learning products and services'. The first few describe

how the appropriation of technology by stakeholders in learning environments can contribute to the evolution of libraries of information, which in turn aid the collective building and sharing of knowledge. The next few emphasize the impact of technology on the development of collaborative and social interactions in learning processes. Finally, a series of papers describes applications that demonstrate the relevance of technology-enhanced learning practices.

The 'technology-enhanced learning' research area, no longer in its infancy, is developing very rapidly in accordance with the tremendous technological progress being made. This evolution paves the way for the elaboration of unpredictable and innovative scenarios of use for technology that increases the integration of social and informational environments based on context-aware services integrating access to heterogeneous information sources.

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*Illustration by courtesy of the TAO project  
- An Open and Versatile Computer-Based  
Assessment Platform Based on  
Semantic Web Technology.  
See article on page 32.*



# Developing Products and Services for E-learning

by Sybille Hambach

*People no longer need to be convinced that e-learning is up to date. However, they still need to know how to develop good e-learning products and services. Researchers at the Fraunhofer Institute for Computer Graphics (IGD) Rostock have developed the process model ROME. It helps experts from different disciplines to understand the process, methods and tools involved in developing e-learning products and services.*

The development process for e-learning products and services is very complex. A variety of concepts, methods, tools and scenarios must be considered in order to choose those most suitable for a specific context. Furthermore, experts from different disciplines will contribute to an e-learning product: the topic expert and experts from pedagogy, computer science and design. Each has his/her own terminology and preferred way of discussing alternatives and deciding on a solution. It would therefore be helpful to have a description of the development process that is suitable for all the experts involved and that integrates all the contributing disciplines.

## Contributing Approaches

We propose that the development process for e-learning products and services be described using approaches from the engineering disciplines:

- the systems engineering approach is used to structure the development process. It implements four basic principles: (1) from coarse to fine, (2) thinking in variations, (3) phase structure as macro-logic, and (4) problem solving as micro-logic.
- a process model is used to describe relevant components, eg process steps, roles, artefacts and resources (methods, tools, standards etc). A sequence of process steps explains exactly what to do or decide, which experts to involve, the results to be achieved and what resources to use.
- description schemata are used to semi-formally describe each component. They are supplemented by UML diagrams showing the relationships between different components of the process model.
- text schemata from the field of technical documentation are used to describe each component in detail. The resulting text or multimedia documents, eg teaser, procedure, example, reference etc, are very structured but easy to read and understand.

While these approaches originate from engineering disciplines, they are easy to understand for experts from other disciplines; in addition, they are also suitable for describing complex development processes.

## The ROME Process Model

Our process model ROME – the Rostock model for systematically develop-

- it provides instructions for the development of an e-learning product that is best suited to the topic, the target group and the specific context.

ROME is suitable for developing e-learning products and services for all kinds of scenarios: blended learning, distance learning, cooperative learning, computer-based training, Web-based



*Introducing computers in a Kindergarten.*

ing e-learning products and services – supports interdisciplinary teams in developing e-learning products and services.

- it provides (and applies) a basic vocabulary for all team members
- it describes what to do and what to consider while developing e-learning products and services
- it integrates concepts, methods and tools of all contributing disciplines

training and so on. ROME conforms to the 'Reference Framework for the Description of Quality Approaches' for e-learning specified in ISO/IEC 19796-1:2005, and was described as a European-wide good practice in CEN CWA 15660:2007.

## Using ROME

ROME has been used to structure a variety of e-learning projects: an educa-

tional concept for introducing computers into a kindergarten (see example below) and a primary school, an e-learning product for teaching the basics of usability, a WBT about safety in the workplace, and a variety of e-learning products and services for teaching software tools. It was even used to develop the game-based training 'Pfeilstorch' about a biological topic. Furthermore, ROME is suitable for teaching the basics of e-learning as well as for implementing software systems to support e-learning projects. It has thus been used to design and prototypically implement electronic performance support systems for interdisciplinary teams developing e-learning products and services.

#### An example: Introducing Computers in a Kindergarten

It seems logical that kindergarten kids (aged 4 to 6) should learn how to use a

computer. They regularly see people working with computers and it makes sense that they should become familiar with the computer as an everyday working tool. Without much background knowledge, one might simply buy a computer and some computer games for kids – perhaps choosing them according to how they rate in relevant rankings. The computer is then plugged in, the games installed and the kids allowed to play.

Using ROME, one would first look at the need (Why should the kids learn how to use the computer? What can they do with it?), at the kids (What do they already know? What are they able to do?) and the context (What do the parents say? What are the teachers' skills? What computers are available or appropriate?). The next step would be to think about appropriate didactic approaches (cooperative, project-oriented, living-world-oriented etc). An

overall concept would be specified, including learning material, scenarios, settings and activities, and some of the aspects would be looked at in more detail. One would speak with parents, teachers, technicians and pedagogical experts to validate the concept. Finally, one would set up the learning material, carry out single lessons and evaluate their success. Overall, this process – performed systematically – is not necessarily more complex but provides significantly better results.

#### Link:

<http://www.igd-r.fraunhofer.de>

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## Collaborative and Engaging Online Learning

by Gavin McArdle, Teresa Monahan and Michela Bertolotto

*The provision of learning facilities online is a convenient way for students to partake in education. This form of e-learning is currently in widespread use and is continually growing in popularity. The CLEV-R research group within the School of Computer Science and Informatics at University College Dublin, Ireland, are examining ways of enhancing students' e-learning experiences by providing interactive methods for accessing e-learning material. Of particular interest is support for a learning community, which permits collaborative learning techniques and fosters social interaction between students. A combination of 3D multi-user environments and instant communication techniques are employed to achieve this.*

Current Web-based e-learning applications tend to focus on the management of learning material and students' access to it. They offer mechanisms for tutors to easily monitor students' actions and assess their progress throughout a course. However, studies show a high attrition rate among courses that are run solely using these techniques. Lack of motivation and stimulation for students as well as little support for interaction and communication with others contribute to this high drop-out rate. Many of the e-learning solutions currently available present the learning material in a plain-text format which fails to engage the student. Furthermore, communication facilities, if present in such e-learning applications, are often asynchronous. This can lead to a sense of isolation and loneliness for students. This issue is further exacerbated by the fact that social

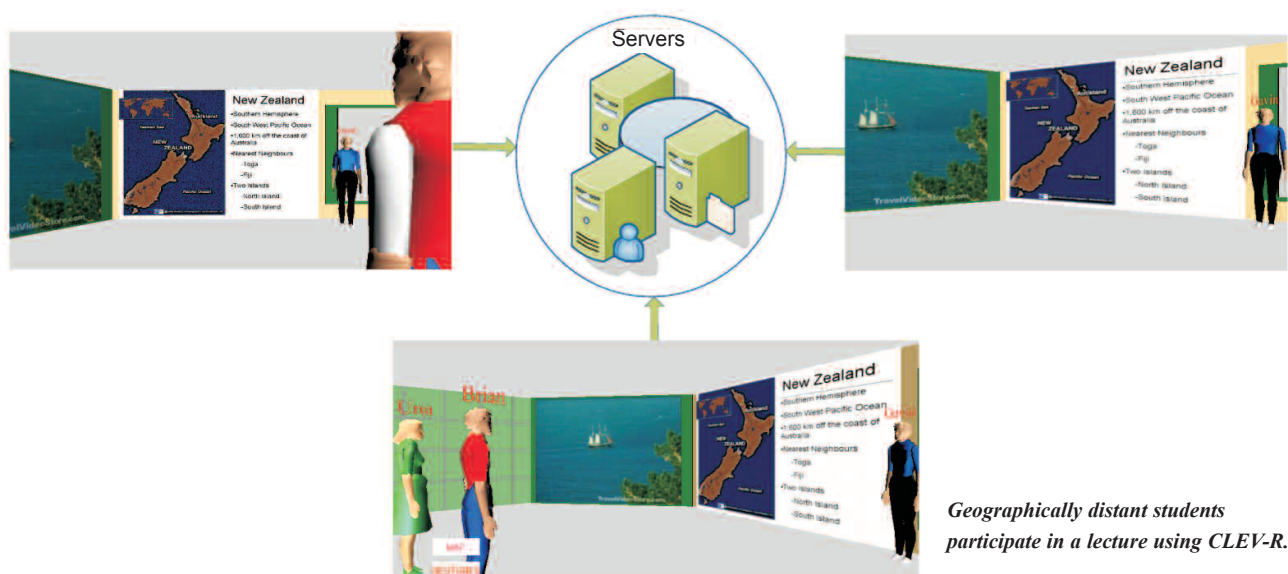
interaction between students, which is prevalent in a traditional classroom based learning scenario, is also absent.

The Collaborative Learning Environments with Virtual Reality (CLEV-R) project at UCD addresses these issues by using a range of technology to support learning while also engaging and stimulating students. Communication technology is used to remove feelings of solitude and introduce collaborative and social aspects to e-learning. Our group is also exploring the possibility of extending these facilities to a mobile platform that would enable users to access learning material and partake in collaborative learning activities without having to remain in a fixed location.

The use of onscreen three-dimensional (3D) graphics to provide an interface to

access e-learning content marks CLEV-R's main departure from mainstream e-learning applications. The interface mimics a university setting and provides the tools and features found in a real university. For example, virtual classrooms, meeting rooms, social areas and a library are all available to students. While the 3D graphics engage the student and offer a novel and exciting means of interaction, the key to the CLEV-R interface is the multi-user features it provides. Each student and tutor takes on the role of a character within a 3D environment; each character and their actions are visible to all users of the system. This creates an awareness of others and removes the sense of isolation often experienced with mainstream e-learning applications. The multi-user aspects of the 3D interface are supported by a number of synchro-





nous communication facilities; these allow students and tutors to interact with each other in real time using a combination of voice and text chat. A mobile interface entitled mCLEV-R supplements this desktop application by providing students with access to the learning facilities via mobile devices. It provides a 3D interface to the learning services via a single-user 3D office-style environment. While the multi-user aspects of the 3D environment in the desktop application are not supported in mCLEV-R, synchronous text and audio communication technology is provided, which allows users to converse in real time.

One of the most powerful features of CLEV-R is the lecture room. This room allows a tutor to present a lecture to a group of students simultaneously. The room contains a presentation board where lecture slides can be displayed, and a media board that can be used to present audio and video material. Instant communication allows a tutor to talk directly to the class and so present a lecture in much the same way as they would in the real world. A live webcam feed can also be utilized to further enhance the learning experience. Additionally, students can use their microphones to talk to the tutor and ask questions. Supplementing these synchronous learning techniques, a library offers a means of individual learning by

providing access to learning material. The 3D environment also contains meeting rooms which provide tools for collaboration among students. Presentation and media boards allow them to share their work, and they can communicate using real-time text and audio communication techniques. As social interaction is an important factor for students, the 3D environment has dedicated areas where students can meet informally. Students can use the instant communication tools in coffee areas to chat to their friends while more specialized tools in social rooms allow them to share photos and videos. Mobile users can also participate in these activities. Through the 3D interface, they can access learning material and course announcements. The real-time communication technology enables them to listen to live lecture commentary, participate in group learning activities and socialize with their peers.

Prototypes of both CLEV-R and mCLEV-R have now been developed, and a user evaluation study was carried out to ascertain people's reaction to them. As expected, the 3D and synchronous communication technology was seen as valuable for engaging students and creating a sense of community for them. These results provide encouragement for the continued exploration of such technology for e-learning and m-learning.

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# HyLearn: Cooperative M-Learning in Hybrid Networks

by Matthias R. Brust, Adrian Andronache and Steffen Rothkugel

*In retrieving information, today's mobile devices are able to connect directly the Internet via UMTS/GSM links, allowing them to consult neighbouring devices by using free-of-charge Bluetooth or Wi-Fi links. Increasing numbers of students are taking advantage of these mobile devices in order to advance in their studies faster and more efficiently. The HyLearn application supports the student in the use of any possible wired or wireless communication link to search for teaching material, and fosters cooperation between students.*

HyLearn is a cooperative learning system for mobile devices running on a hybrid wireless network. HyLearn allows students to develop personalized sets of their teaching material (see Figure 1), including annotations, questions and links. HyLearn deploys information to interested nodes through both fixed and mobile networks. Due to the mobility of nodes, an efficient approach to ad hoc self-organization is required. We apply a clustering technique that forms hierarchical structures of an otherwise homogeneous ad hoc network. This multi-hop clustering algorithm is parameterized in terms of cluster size and can therefore adapt to the mobility degree of nodes. Only local information is required to establish and maintain clusters. The algorithm is based on HyLearn's expected communication pattern.

The HyLearn application applies the well-known podcast mechanism to disseminate information. A podcast is a

multimedia file distributed over the Internet using the syndication feeds mechanism. The provider – known as a podcaster – creates the content and posts the information on a Web server. The episode is posted as an element of a syndication feed in RSS format, which provides information about the series and its episodes: publishing date, title, description and so on.

The teaching context is a common set of lecture-related information, initially distributed by the lecturer in the form of podcasts. Running on students' devices, the HyLearn application will discover the new podcast in the ad hoc network and enable the students to subscribe to it. This will instantly provide them with the lecture material from the teachers' notebook, without needing to use an Internet connection.

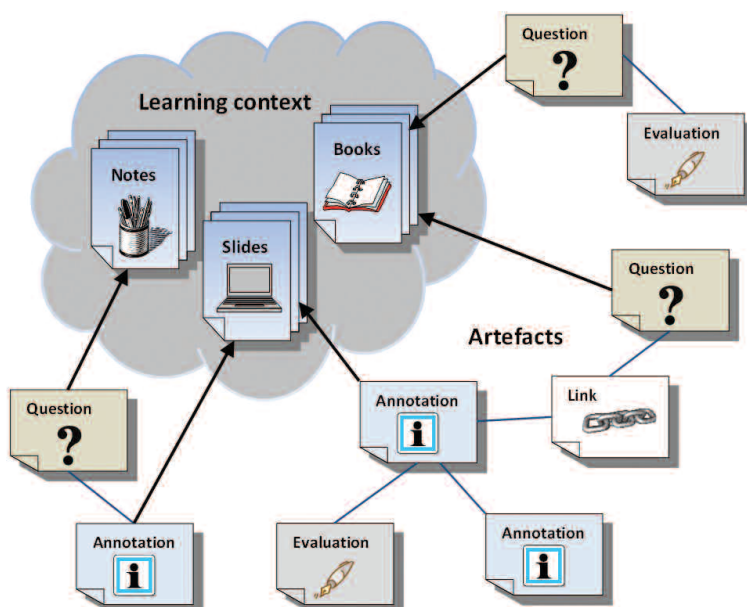
Students can also use HyLearn to augment the teaching material by adding

student-created artefacts, thus creating their own episodes of the podcast.

When studying the material later on, students can use questions added by the teacher or their own questions to gain a deeper understanding of the topics covered. They are also encouraged to add annotations to the teaching material, slides, and questions.

Moreover, students may discover additional relationships between some sections of the teaching material, their annotations, and the questions, and can add these as links. While using the application, the subset of available material can be augmented by meeting other students. Students are able to evaluate artefacts with respect to their usefulness, in order to prevent misleading or false supplements to the teaching material from being distributed. Students can use the system during and after lectures, are able to join interest groups by sharing their material, and can help each other in a cooperative and collaborative way, such as in preparing for exams.

Managing the teaching material together with the data added by students is a challenging task. We assume that students at different universities will have different lectures and learning material related to the same topic. Thus, all participating devices can form multiple ad hoc network partitions over time. HyLearn enables students to search foreign networks such as ad hoc networks on other university campuses for podcasts related to their current interest. To achieve this, HyLearn organizes the ad hoc networks into clusters by electing local leaders called clusterheads that maintain uplinks to a backbone server. Only devices with a backbone connection will be elected as clusterheads. HyLearn users can search for podcasts by entering keywords



**Figure 1:** Learning material is distributed to students, who can attach to it artefacts such as questions, annotations and links. Artefacts can be evaluated by participants.

related to the lecture of interest: HyLearn then sends the search query to the local clusterhead, which will forward it to the backbone.

The HyLearn backbone will inject the search query to all registered clusterheads, thus querying devices in different networks and network partitions. When a clusterhead receives a search query, it sends it to neighbouring ad hoc devices, thus performing a local search. The podcast feeds on the network devices that match the keywords of the query will be

sent to the backbone via the local clusterhead. The backbone forwards the matching feeds to the requesting device and caches the podcast to satisfy further search queries directly. HyLearn uses a cluster topology in the ad hoc networks in order to minimize the number of uplink devices in a partition. This in turn reduces the number of search queries sent to a network partition as well as the number of redundant results sent to the backbone from a network partition. For this, we developed a k-hop clustering algorithm. The algorithm is shown to be

highly adaptive to mobility and works with local 1-hop neighborhood information only, asynchronously and in a fully distributed fashion.

#### Links:

<http://mocca.uni.lu>

<http://hymn.uni.lu>

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## The MOSEP E-Portfolio Course: A New Didactic Concept for Teachers and Vocational Trainers

by Wolf Hilzensauer

*Some hail e-portfolios as the answer to their prayers for a method of competence-oriented learning. This is because e-portfolios combine classical (course-oriented and/or blended) e-learning with self-organized, self-oriented and lifelong learning. What competencies do teachers need in order to support learners in their individual learning processes? The European project MOSEP (more self esteem with my e-portfolio) tries to come up with some of the answers.*

The search for supportive tools and strategies for learning is as old as learning itself. According to Cohn & Hibbits (Beyond the Electronic Portfolio: A Lifetime Personal Webspace, EDUCAUSE QUARTERLY, Number 4, 2004, pp 7-10) 'knowledgeable slaves' had to accompany Roman boys in ancient times to school, to support them in their learning and to help them memorize the schoolwork they had done. In the 1940s, Vannevar Bush developed the idea of a 'memex', an electronic system which would automatically link related pieces of information in order that they might be stored in a meaningful way. In today's literature also, tools to support thinking are imagined. For instance, Albus Dumbledore, headmaster in J.K. Rowling's Harry Potter series, uses a thing called a 'pensieve', which is used to store unimportant thoughts so that he can concentrate on the important ones. If they are needed later, he can recall them, giving him the ability to focus his mind.

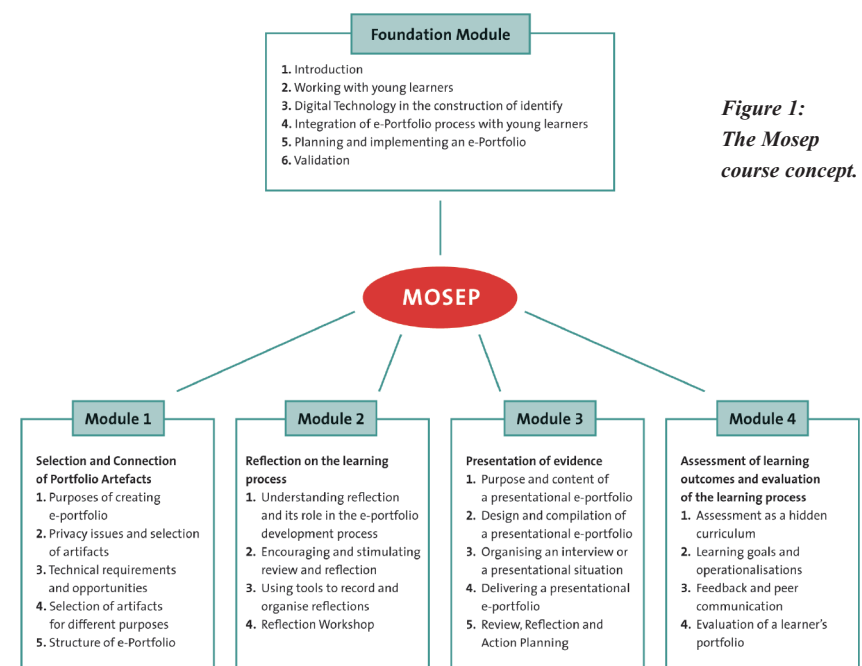
E-portfolios can be defined as "a purposeful collection of student (or teacher) work that illustrates efforts, progress and achievement in one or more areas over time. An electronic portfolio uses digital technologies, allowing the portfolio developer to collect and organize portfolio artifacts in many media types (audio, video, graphics, text)." (Barrett, 2005)

When working with e-portfolios, the focus (contrary to classical learning management systems) lies in the combination of storing both the products and the process of learning. The documentation of learning processes is achieved

by recording reflections on the learning progress of individuals.

#### Implementing e-Portfolios in an Educational Context

When working with e-portfolios in an educational context, it is important to not only introduce the method (and an appropriate tool), but to also implement



**Figure 1:**  
*The Mosep course concept.*

e-portfolios as an overall concept. In doing so, one must consider the existing curricular system, the objectives of the educational context (targets and outcomes) and the technological and organizational requirements. In addition (and this is the MOSEP idea), teachers and tutors require specific skills and must adapt their classical teaching methods to create an open, flexible learning partnership between teacher/tutor and learner.

Successful implementation of the e-portfolio approach demands a different approach to teaching and learning. Teachers need strategies to support learners in creating and maintaining their e-portfolios, and in evaluating the outcomes. For the learners, the challenge is to acquire the necessary skills to build a portfolio and, more fundamentally, to develop the ability to reflect on and accept greater responsibility for their own professional development.

#### MOSEP: The E-portfolio Course for Teachers and Vocational Counsellors

MOSEP is a European project, funded by the Leonardo da Vinci Programme (Pilot Projects II – Duration: 2006-2008). The project is harnessing the power of e-portfolios to support young people and the teaching and counselling staff who work with them. A strong European partnership – from Austria, Bulgaria, France,

Germany, Lithuania, Poland and the UK – is working closely with a network of experts across Europe to produce an e-portfolio ‘toolkit’ specifically designed for initial and in-service teacher trainers and vocational counsellors.

Our newly developed didactic approach provides a set of self-explanatory training material, which can be used, reused and adapted according to an institution’s needs. All materials are freely and openly available via a Wiki system, which provides semantically enhanced resources, a guided tour, a predefined pathway through the system, and trainer guidelines and multimedia resources.

#### The MOSEP Toolkit

The following products will be available for use by schools and organizations responsible for teacher training and vocational counselling:

- a study outlining the qualifications and skills required by teachers/tutors working with adolescent learners
- the MOSEP e-portfolio course for teachers/tutors and vocational counsellors
- a teacher-training package providing guidelines and assignments that teachers can use with their students
- an online forum for teachers/tutors providing help in the use of this material and in the selection, installation

and implementation of an open-source e-portfolio tool for their students.

#### Future Steps

Beginning in autumn 2007, the testing period will be used to evaluate the MOSEP course in five different countries and in five different languages: English, German, Polish, Lithuanian and Bulgarian. All materials will be translated and adapted, revised and finalized by spring 2008. The final conference will take place in June 2008 in Salzburg, where the results will be presented, and the future development of e-portfolios and the concept of self-directed and life-long learning will be discussed.

#### Links:

<http://edumedia.salzburgresearch.at>  
<http://www.mosep.org>  
Barrett, H. (2005). *Portfolios For Learning*: [http://electronicportfolios.org/blog/2005\\_05\\_01\\_eportfolios\\_archive.html](http://electronicportfolios.org/blog/2005_05_01_eportfolios_archive.html)  
*The MOSEP Study: Grab your future with an e-portfolio*:  
<http://www.mosep.org/study>

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## Open Educational Resources: Features, Trends and Implications

by Guntram Geser and Sandra Schaffert

***Open content in education and learning has increasingly gained attention in recent years. Its importance has been acknowledged by stakeholder organizations, and recent international initiatives are fostering the creation and sharing of such resources. The EU-project OLCOS observes the trends and implications of open content for learning and education, and offers guidelines and resources for teachers, learners, educational institutions and decision makers.***

For many years now considerable investments have been made to equip educational institutions with computers, software programs, local area networks and Internet access. Recently, policy emphasis has switched from infrastructure and connectivity to content, services and practical usage. This switch necessitates a stronger commitment from the directors, managers and staff of educational institutions regarding educational innovation and organizational change.

The investments made in ICT-enabled teaching and learning have not yet brought about the profound changes in educational practices that would better align educational institutions with the requirements of the knowledge society. In addition, there is an obvious gap between current educational practices and those tools used so naturally by the younger generation. While blogs, Wikis and podcasts are used to communicate and to form communities of interest,

these activities happen almost exclusively outside the classroom and thus outside the traditional learning environment.

#### Open Educational Resources

Open Educational Resources (OER) comprise content for teaching and learning, software-based tools and services, and licences that allow open development and reuse of content, tools and services. The importance of OER

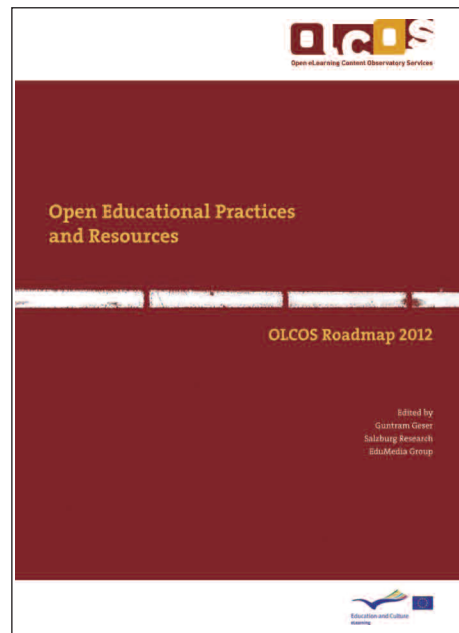
has been acknowledged by recent initiatives of the OECD's Centre for Educational Research and Innovation, UNESCO's International Institute for Educational Planning, and other national and international organizations that are stakeholders in the creation and sharing of such resources.

The importance of digital resources stems from the fact that these resources are fundamental to the knowledge society and economy. It is therefore essential that teachers and students become proficient with digital tools and services, and that they are aware of the various content licences. This proficiency is vital because within the digital realm content cannot be created, reused or shared without employing tools and services. Moreover, content licences are important because they define what the authors – who hold intellectual property rights (IPR) such as copyright – are willing to grant others who wish to benefit from the investment made in developing the content. There is an established understanding that easy access to educational resources is required to promote lifelong learning in people of all ages. The role of such access in reducing social inequalities, fostering social inclusion of migrants, and supporting education in developing countries is also often emphasized.

Additionally, when used in didactically sound ways, software-based tools, services and multimedia can allow innovative educational practices to emerge. For example, new educational opportunities may arise in a digitally enhanced collaboration between teachers and learners. Unfortunately, there exists a significant gap in teachers' knowledge of how to use digital resources most effectively. We expect that this gap will be closed within communities of practice by teachers with the right professional attitude sharing their experience. Again, open access to resources is an important element in educational innovation, but it is not the only solution. The decisive factor is that open educational practices should be fostered by the appropriate institutional culture. Such a supportive environment should include easily accessible and shareable tools, services and content.

### The OLCOS Project and Materials

Since early last year, the Open e-Learning Content Observatory Services



*Open Educational Practices and Resources. OLCOS Roadmap 2012. The report is based on own research work, expert workshops and other consultations with many international projects that promote the creation, sharing and re-use of Open Educational Resources. Available from the OLCOS web site.*

(OLCOS) project has explored how Open Educational Resources (OER) can make a difference in teaching and learning. The project runs from January 2006 to December 2007 and is cofunded by the European Commission under the e-Learning Programme. The project consortium comprises the European Centre for Media Competence (Germany), the European Distance and E-Learning Network (EDEN Hungary), the FernUniversität in Hagen (Germany), the Mediamasteri Group (Finland), the Open University of Catalonia (Spain), and the project coordinator Salzburg Research, EduMedia Group (Austria).

The project will employ a range of activities to promote Open Educational Resources. OLCOS has produced a roadmap that will help educational decision makers to familiarize themselves with OER and provide them with recommendations on how to foster its use and further development. This study can be downloaded for free (see link below). Besides these recommendations, the OLCOS project is also developing free online tutorials for practitioners. The objective of this online book is to support students and teachers in the creation, reuse and sharing of open educational resources.

Our initial findings show that OER can play an important role in teaching and learning. However, current educational practices will determine whether – and how – digital educational content, tools and services will be deployed and utilized. If the prevailing practice of

teacher-centred knowledge transfer remains dominant, then OER will have little effect on innovation in teaching and learning. It is therefore also crucial to promote innovation and change in educational practices.

From a pedagogical perspective, the key aspects of ICT-supported lifelong learning and OER are that self-directed learning is emphasized, and that there is much potential for novel approaches of collaborative knowledge development. Such approaches are more likely to evolve in learning settings other than traditional forms of formal education, which still show few signs of abandoning the teacher-centred paradigm of education. However, in ICT supported lifelong learning, the role of coaches and communication among peers will need to be given much more attention and consideration. Those who have the greatest need for access to lifelong learning resources may not always be prepared for fully self-directed learning.

### Links:

<http://www.olcos.org>

*OLCOS Tutorials:*

<http://www.wikieducator.org/>

*Open\_Educational\_Content*

*EduMedia Group Salzburg Research:*

<http://edumedia.salzburgresearch.at>

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# User-Centred Learning Object Metadata for Effective and Efficient E-learning Environments

by Anne Morris, Ann O'Brien and Panos Balatsoukas

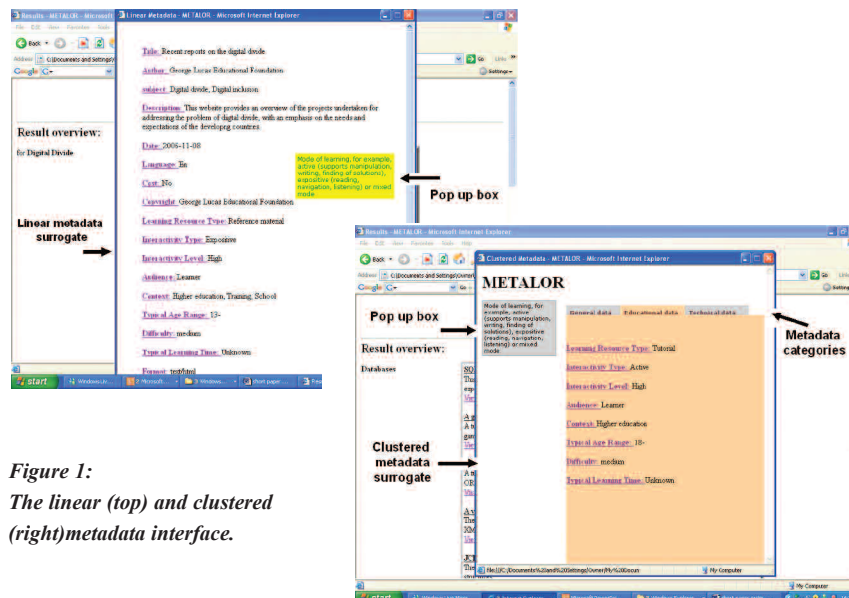
*Research conducted in the Department of Information Science at Loughborough University in investigating the evaluation and design of usable schemes for learning object metadata.*

Learning object metadata can be defined as structured data used for the efficient description of learning objects and the effective support of educational functions related to those objects. There are several metadata standards and schemas available for the description of learning objects, such as the LOM (Learning Object Metadata) and the DC-ed (Dublin Core – Education). The use of high-quality and usable learning object metadata has significant implications for the development of e-learning infrastructure in UK higher education. These include:

- the realization of an e-learning infrastructure based on a vision of the semantic Web
- more accurate retrieval of learning objects within and across individual institutions
- improved searchability and relevance evaluation of learning objects in search and search-result interfaces of e-learning systems, such as educational digital libraries
- increased reusability of learning objects and learning content in various instructional contexts (learning object economy)
- adaptability and personalized delivery of learning content according to users' needs
- management and preservation of the contents of Learning Object Repositories (LORs).

Currently, research on learning object metadata is dominated by an interest in interoperability and standardization issues, and the social and human aspects of metadata implementation have been neglected. Research into users' needs in relation to learning object metadata is therefore needed.

The aim of the work currently being undertaken in the Department of Information Science at Loughborough University is to investigate the way in which learning object metadata should be designed to meet the needs of university students and teachers in the UK.



**Figure 1:**  
*The linear (top) and clustered (right) metadata interface.*

In particular, the objectives of the project are:

1. To explore the level of uptake of learning object metadata among UK universities and develop a roadmap of metadata research activity in the UK.
2. To improve the semantics of existing learning object metadata standards, such as LOM, and design a user-centred learning object metadata application profile.
3. To develop a set of recommendations and guidelines for the design of interfaces of e-learning systems that represent learning object metadata. There are three types of interface that are of particular interest: interfaces of metadata authoring and editing tools; metadata-driven search interfaces; and search result interfaces. These types of interface are present in Learning Object Repositories, Educational Digital Libraries and Virtual Learning Environments (VLEs).
4. To develop and apply a methodological framework for design research on learning object metadata.

The project involves academic staff and research students from within the department. The key members of the project are Professor Anne Morris, Dr. Ann O'Brien and Panos Balatsoukas.

The group's expertise covers various research domains including e-learning, knowledge management, human computer interaction, information processing, and metadata and relevance judgment research.

Since the beginning of this project (December 2005), several studies have been conducted. One experiment investigated students' interactions with two different learning object metadata-driven search result interfaces: a linear metadata surrogate interface and a clustered metadata surrogate interface (see Figure 1). The results of this study revealed that participants were significantly more satisfied with the clustered interface. This interface minimized users' cognitive load when judging the relevance of learning objects.

A survey was conducted on the use of the LOM standard in the JORUM repository. The results of this study revealed limited use of metadata elements describing the structure and aggregation level of a learning object as well as metadata about the relationship between learning objects. Furthermore, the study revealed that certain educational metadata elements tended to be more frequently used for the description of learn-

ing objects from the Humanities and Social Sciences than other disciplines.

Another survey investigated students' perceptions of the importance of certain metadata elements of the LOM standard in the selection of learning objects. Some preliminary findings revealed that students generally preferred the educational and content-related metadata to technical metadata and metadata about the structure of a learning object.

Research is in progress to investigate students' interactions with three Learning Object Repositories (JORUM,

MERLOT and ARIADNE). Future research will concentrate on the needs of university teachers in relation to learning object metadata, as well as the design of a collaborative learning object metadata creation system for the UK higher education system.

Our research team has developed a methodological framework that adopts both a behavioural and design research approach. These approaches support the development and evaluation of theories and artefacts (eg metadata application profiles and prototype systems). Within this framework a variety of research

methods have been employed, such as experiments, usability tests, user studies and online surveys. The data collected has been analysed within a positivist research tradition. It is anticipated that the findings, artefacts and methodological framework of this project will inform the design and evaluation of user-centred learning object metadata in the European Union and support comparisons between countries.

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## InterEDU: Supplying Teachers and Students with Educational Resources

by Erich Gams and Georg Güntner

*Intelligent Edumedia Repository (InterEDU), a project conducted at Salzburg NewMediaLab (SNML), is developing a framework for an online platform for educational multimedia content. This is based on semantic Web and social software technology which is applied in the project to improve searchability (eg by semantically interrelating content) and to enhance the usability and attractiveness of content by combining the collective expertise of the learning and teaching community.*

Both teachers and learners are increasingly using the vast range of educational multimedia content that is available on the World Wide Web and in specific databases. Most resources do not exactly fit their personal requirements and thus need to be adapted or merged. In the InterEDU project, Salzburg Research (a non-profit research organization), punkt.net services (a provider of knowledge software), and Education Highway (Austria's largest online provider of educational resources), offer a broad collection of videos, texts and images to teachers via the WWW. The growing amount of multimedia content and the heterogeneous access points of our partner's content management system (CMS) inhibit efficient search and navigation, making it difficult for users to find relevant content. The existing CMS, which has been adapted and enhanced several times, struggles with heterogeneity and the distribution of content and metadata over several repositories. The systems currently in use do not consistently support desirable features such as full-text search across all media types, or browsing based on taxonomies that adapt to new content. Furthermore, the current system

does not support collaborative creation, sharing or enhancement of educational content.

### Objectives

InterEDU is a three-year project split into three phases. Based on an incremental approach, each phase has its own defined goals and objectives which will be evaluated by the users. The first phase – currently in progress – is dedicated to semantic functionalities and tagging. The second phase will address the collaborative generation of content and the third phase will focus on social networking and quality assurance aspects. Overall our project is developing a framework for an online platform for educational multimedia content (EduMedia repository) that supports:

- the organization and composition of learning material
- reuse and search of multimedia content
- discourse about learning materials
- collaboration between teachers by applying semantic Web and Social Software technology.

It is not our intention to reinvent another CMS, but rather to enhance an existing

CMS with semantic and social semantic Web functionalities. In each phase the functionality of the prototype will be successively enhanced with semantic Web technology, such as ontologies to file, search and find relevant content. Social Web or Web 2.0 methods will help us to personalize and socialize content management and to help people assess and improve content quality.

### Scientific Approach

The scientific approach taken by the project is to construct an adaptive ontology for the domain knowledge of the users by annotating learning material or assigning learning material to categories or concepts defined in a background ontology. The domain model created by the collective experience of the users enables existing and newly generated content to be associated with its context, which leads both to new connections between learning materials, and to semantically supported search and navigation. The project creates a single point of access which mediates between different standards such as the learning objects metadata standard (LOM, IEEE 1484.12.1-2002)



*Delivering educational multimedia content.*

and the metadata extension as proposed for school material (a national standard issued by the Austrian Federal Ministry for Education). User annotations allow users to assess the quality of individual learning units, and to exchange information about relevant topics. An integrated quality rating framework will support content consumers by assessing the overall quality of the content they would like to use.

### Outlook and Results

Based on the objectives, the project partners have introduced different use cases that will be evaluated with a prototype implementation. On the basis of the requirements for a CMS we have developed a modular reference architecture and a data model for a generic semantic CMS. A novel aspect of our approach is the clear separation of content in the AssetStore and metadata in the Triple-

Store, accessible by a component called Knowledgebase Manager. Hence, all metadata is modelled in a (modular) ontology, which enables a unified interface for reasoning. For the implementation of our architecture we choose a Service-oriented Architecture (SOA)-based approach, as a SOA is well suited for migrating the monolithic architecture of our legacy CMS to a modular semantic CMS architecture. Currently, we are working on a prototype that provides a personal workspace in which each user is able to manage the collaborative creation and sharing of content, and the search for related content.

InterEDU is a project of Salzburg New-MediaLab, an industrial competence centre in the Kind programme funded by the Austrian Ministry of Economics and Labour (BMWA) and the State of Salzburg.

### Link:

<http://www.newmedialab.at>

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## The Web Geographic Information System for Culture as Preliminary Learning Phase

by Carola Salis and Eva Lorrai

*Among its several branches, the Centre for Advanced Studies, Research and Development in Sardinia has a department which focuses on the research and development of remote tools for e-learning. The aim of the Web Geographic Information System (Web-GIS) for Culture (WGC) project is to create a database of Sardinian museums that will provide school teachers with useful and detailed information about the nature of the exhibit characteristics and the related activities, thereby helping students to derive the greatest benefit from their museum visits. The WGC is a methodological and technological framework that, once established, will enable access to and updates of museum activities.*

In selecting suitable cultural events for their pupils and preparing them to assimilate new knowledge, teachers face considerable difficulties. Despite the obviously practical nature of a museum visit, in the case of many students it still fails to stimulate any significant construction of cultural knowledge. Virtual museum environments are becoming more common, and according to Dillon this phenomenon increases the involvement of

visitors by better preparing them for the real visit. Good examples are given by the museum of Alaska in its geo-historical aspects or the Cité des Sciences et des Technologies (a scientific and technological museum) of la Villette in France. In these examples, didactic activities to be completed before and after the visit have been created, thereby guaranteeing a complete cycle of learning. Along similar lines, the WGC system should offer an

innovative opportunity within the Sardinian education system.

### Technology and Features of the WGC System

The database will be presented in a Web-GIS form. In this way, the system will be introduced in a territorial context, and integrated with many other information layers. The Open GIS Consortium (OGC) Geography Markup



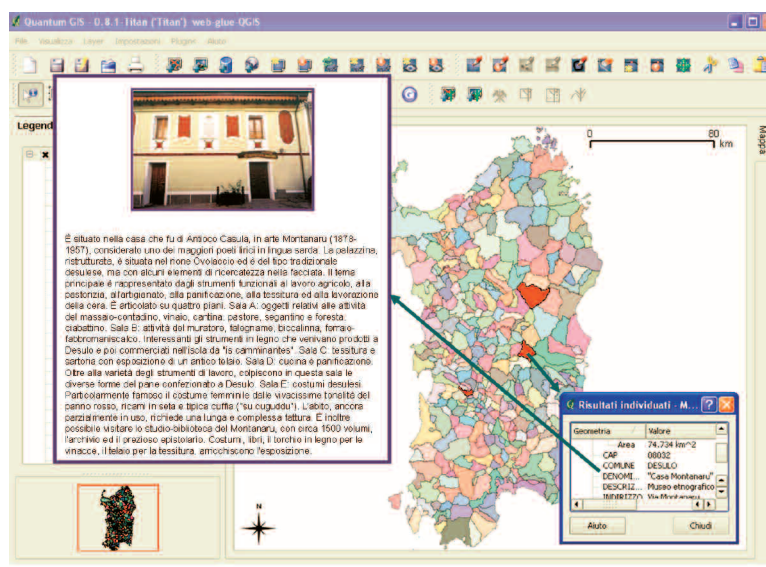
Language Implementation Specification describes an encoding specification for geodata in XML that enables the storage, transport, processing and transformation of geographic information. The specification defines interfaces for data access and manipulation operations on geographic features, using HTTP as the distributed computing platform. Via these interfaces, a Web user or service can combine, use and manage geodata (the feature information behind a map image) from different sources. For the development of WGC the University of Minnesota MapServer has been chosen as the development environment for building spatially enabled internet applications.

The following components have been selected for the GEM application:

- Apache HTTP server
- PHP
- MapServer CGI (Common Gateway Interface)
- PHP/MapScript
- GDAL (Geospatial Data Abstraction Library)/OGR utilities: GDAL is a translator library for raster geospatial data formats that is released under an open source licence. As a library, it presents a single abstract data model to the calling application for all supported formats. The related OGR library (which lives within the GDAL source tree) provides a similar capability for simple features vector data. UMN MapServer can use GDAL to access TIFF/GeoTIFF, EPPL7 and many other formats, and OGR to access ESRI Shapefiles, PostGIS, ESRI ArcSDE, Oracle Spatial, MySQL and many others.
- MapServer utilities
- OGR/PHP extension
- OWTChart: the OWTChart Engine produces GIF images of virtually any type of chart from a set of input parameters. The program can be used as a CGI in a Web server environment.

Crossing access queries is a peculiarity of GIS database organization, which is a powerful tool for retrieving data and a very helpful approach to making decisions, especially when teachers must deal with large quantities of data. The WGC system will present the following access entries:

- geographical area
- theme
- authors
- pedagogical objectives/activities



#### Museum localization.

- virtual pathway through the museum
- museum classification.

#### Piloting the Experimentation

The WGC development started last April and we plan to initiate experimentation before the end of this year. At least 120 students will be involved in the WGC experiments. They will start with the preparation phase of the visit to a museum chosen by their teacher. They will continue with the real visit to the museum, followed by the online didactic activities with participation in a virtual game through the WGC system and, finally, will take part in the whole evaluation phase (learning evaluation, level of appreciation, level of participation). Half of the 120 subjects will constitute the control group (CG). Twenty primary school children will visit the Museum of Traditional Toys situated in Ales, while a further twenty will represent the control group. Twenty lower high-school

pupils will visit the Art Museum of Nuoro (MAN) and the same number of subjects will constitute the CG. Twenty students of the classical lyceum will visit the house museum Montanaru Desulo and again, the same number of subjects will constitute the related CG. We plan to produce the last report on the WGC application in June 2008.

#### Links:

<http://www.crs4.it>  
<http://opensource.crs4.it/ict/doku.php>

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# Supporting Organizational Learning: AnaXagora

by Sandrine Reiter, Brice Bucciarelli and Luc Vandenabeele

Several surveys conducted in Luxembourg by the CRP Henri Tudor have found that poor or limited use of e-learning occurs in business and commerce when training is inadequate for the needs of small and medium enterprises (SMEs). Nowadays, companies ask for tools that give their employees the opportunity to develop their competencies in relation to their specific business. To satisfy such requests, training tools should be designed to reflect the core business processes of the relevant firm, and should be adapted to cope with different skill levels. CRP Henri Tudor is currently developing AnaXagora, an open-source platform consisting of four modules that can be used to design business processes, manage knowledge and competencies and follow e-learning courses.

During 2002, in the framework of a Leonardo project (ITEMA), the CRP Henri Tudor developed an e-learning management system (LMS) based on the open-source LMS, Ganesha 1.2. Several modifications were made and new functionalities were added, such as a course navigation menu, personalized learning path based on the learner's needs, user rights management and compliance with the Sharable Content Object Reference Model (SCORM).

However, e-learning surveys conducted in Luxembourg companies showed poor uptake of e-learning, reflecting an inadequacy in existing software solutions for the requirements of SMEs, and particularly the lack of specific solutions. E-learning implies an active involvement of learners in their own training, and should therefore be more oriented towards business processes and closer to employees' activities. As the European commission put forward, "the professionals – suppliers of e-learning – should offer innovating solutions to meet SMEs' specific needs".

Based on all these observations, the CRP Henri Tudor is developing AnaXagora, an innovative platform that integrates four different modules (BPM-Business Process Management-, HR-Human Resources-, LMS-Learning Management System- and KM-Knowledge Management-). The goal of this platform is to allow firms to describe and manage their core business competencies in one unique tool. However, each open-source module of AnaXagora also functions as a complete standalone application, and was developed separately by reusing and enriching existing open-source components

The BPM module allows business processes to be represented graphically in terms of a list of activities that may or

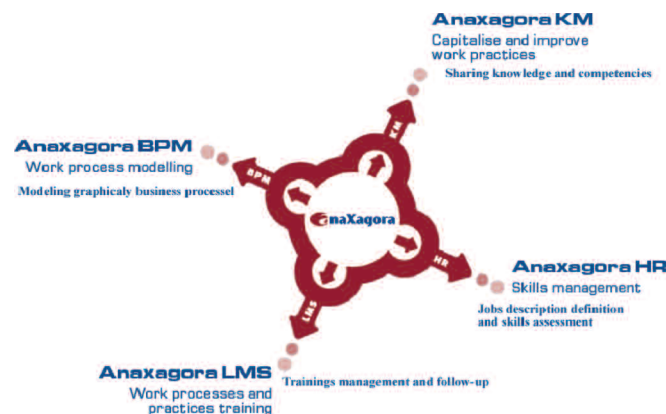


Figure 1:  
The AnaXagora  
platform.

may not be in sequence. This module is based on the SPEM (Software Process Engineering Metamodel) framework but is also compatible with definitions given by the norm ISO 15504. A process is graphically represented within an activity diagram, which shows the logical sequence of activities. Each activity is then assigned a role; this responsibility of a role towards an activity is represented on the flow chart diagram. For example, Figures 2 and 3 show the description of a small part of

the process of 'project management in a computer science SME'.

Here, the project manager is responsible for the activity 'project follow-up', and hence requires the appropriate competencies to correctly perform the work.

The HR module is dedicated to the definition of these competencies via the 'jobs description'. Each activity defined in BPM for a given role, is described by the list of tasks that the role should

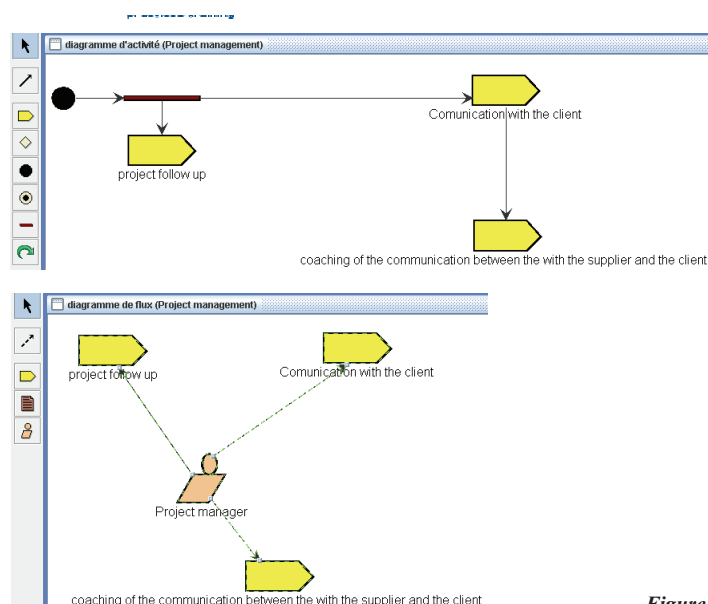


Figure 2:  
Activity  
diagram.

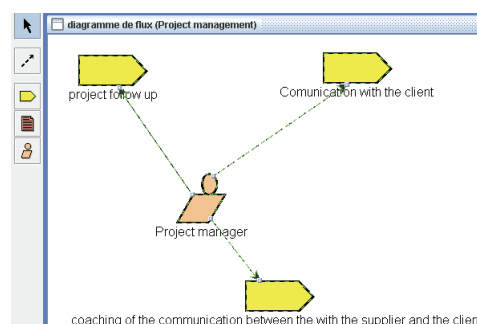


Figure 3: Flow diagram.

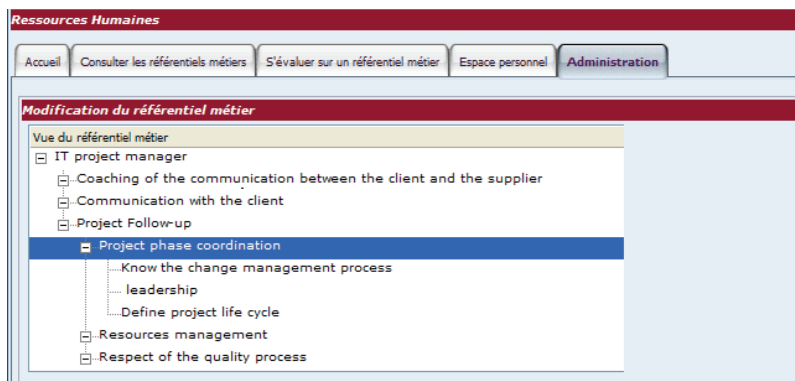


Figure 4: HR module screen shot.

achieve. For each task, the list of competencies is then divided into three different types: 'knowledge', 'know-how' and 'savoir-être'

Returning to the 'project management' example, in realizing the activity 'project follow-up', different tasks like project phases coordination or resources management must be achieved. To achieve the first of these – project phases coordination – the project manager should have leadership (savoir-être), should define the project lifecycle (know-how) and should be aware of methodology that supports this lifecycle definition (knowledge). Figure 4 shows a part of the frame of reference for the 'project manager' in the Anaxagora HR module.

However, representing job descriptions is not enough. Companies are more concerned with the evaluation of their employees' competencies than with simply defining them. As a consequence, the HR module also includes an assessment solution.

A questionnaire is associated with each job description, and can be performed as a self-assessment. This can be done either on the entire frame of reference or on part of it (activity level or task level).

Through the HR module, companies can identify competencies that must be developed and then define new and specific e-learning courses in the LMS module. The LMS allows learners to follow online courses, teachers to sup-

port and help learners in their progression through a course, and authors to manage the course content. Information coming from the BPM, HR and LMS modules is capitalized in the KM module. This module also allows users to visualize existing frames of reference, job descriptions, and the courses available. Within the KM module, users can also share information that could be useful to others (best practices, for example).

AnaXagora development orientations are driven by experiments conducted in a variety of administrations and institutions (Ministère de l'Economie et du Commerce extérieur de Luxembourg, European Bank of Investment), companies (Institut Européen de Formation en Santé) and universities. Future work will be concentrated on a better integration of the four modules, particularly through a Web portal where users can select the services they need.

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## The KP-Lab Framework for Knowledge Creation Practices

by Dimitris Kotzinos, Vassilis Christophides and Liisa Ilomäki

**KP-Lab (Knowledge Practices Laboratory) is an EU-funded project involving 22 partners from 14 countries. It focuses on studying learning practices in professional and educational environments, cross-fertilizing them, and creating the necessary tools to support emerging practices through sharing and collaboration.**

KP-Lab has two aims; first, we wish to understand how, in long-term processes, people collaboratively develop novel epistemic artefacts and transform their knowledge practices both in higher education and professional environments. In addition, we wish to understand how we can cross-fertilize these practices in order to solve complex, authentic problems with the help of innovative educational technology. Second, based on this understanding, KP-Lab aims to develop tools to help these new working and learning practices. While modern infor-

mation and communication technology facilitates knowledge creation around shared objects, it also creates and enhances the need to develop a structured approach, which we call dialogical learning.

### KP-Lab Platform's Architecture

The objective of the ICT-related research and development work in KP-Lab is to provide a technical platform and a set of tools integrated to that platform to support collaborative innovative knowledge practices. The KP-Lab plat-

form will provide a flexible Web 2.0 Service-Oriented Architecture (SOA). This will allow for integration and interoperability for internally developed and external tools that provide sufficient access APIs to facilitate their integration with the platform. The platform is designed also to be both scalable and extensible, so that it can cope with future requirements emerging from its use during and after the project. It will be built on common semantic data models that describe the semantics of the knowledge objects being exchanged.

We can identify three basic layers in the KP-Lab platform architecture. Using these layers one can easily identify dependencies among the different components of the platform and the information flow that is observed in the platform. This is based on the fact that services rely on other services that belong to the same or lower levels in the architecture.

*The Lower (Core Services) layer* includes basic services relating to multimedia, real-time communication, content management and knowledge management. Multimedia services allow for the manipulation of multimedia

want to support. Thus we have awareness services that expose users' presence in the system and their use of knowledge artefacts; annotation services that support semantic and multimedia annotation (thus covering both tacit and explicit knowledge); and portal services that support partition of the knowledge artefacts into shared spaces within which users can share, browse or process these artefacts as individuals or groups.

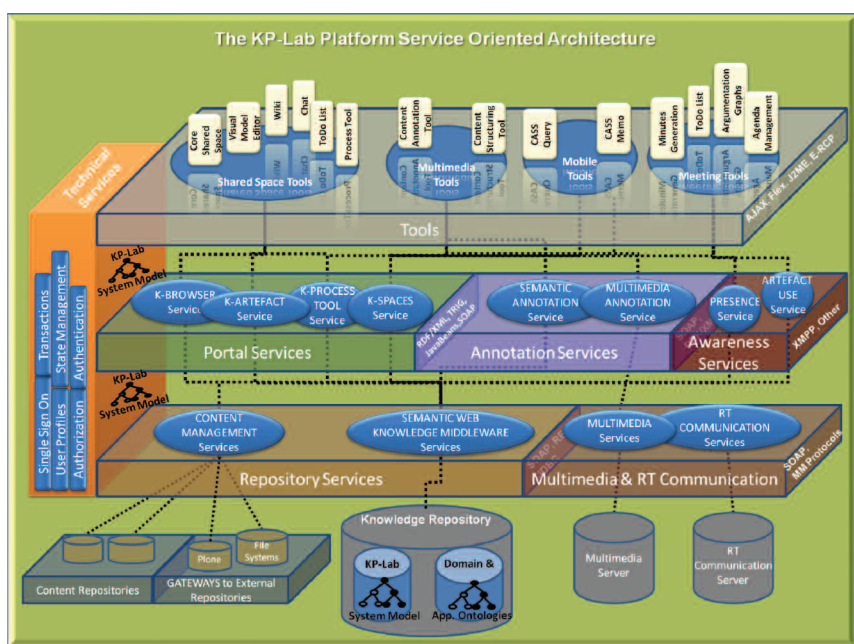
*The Upper (Tools) layer* includes the actual tools that use the described services and perform a single, well-defined task. These tools can be shared and

form are described in the KP-Lab system model, which provides semantic descriptions for them and their interactions in a formal schema (ontology). Thus the components of the platform have a common language using which they can exchange information and understand one another.

### Current Status and Future Work

Parts of this architecture are currently being developed by the KP-Lab consortium. These are mainly concentrated around two areas: the Semantic Web Knowledge Middleware Services (SWKM), which support handling of explicit knowledge; and portal services, which give the user application the ability to define its own shared spaces, populate them with other users and knowledge artefacts retrieved from the knowledge repository, and manipulate these knowledge artefacts in order to create new knowledge.

Planning for the near future includes enhancing SWKM with knowledge-change management capabilities; advancing the content management services to support more content repositories; supporting multimedia and semantic annotation in a coherent way across the platform; and exploiting the real-time communication services to support synchronous e-meetings. Moreover, the KP-Lab platform will be compatible with Web 2.0 technologies in order to better support and facilitate the community and the collaborative features planned for end-user tools in the near future.



KP-Lab platform components.

resources. Real-time communication services allow for users or user applications to interact in real time. Content management services facilitate access to content repositories (both internal and external to the project). Semantic Web knowledge middleware services (for knowledge capture, access, distribution, development and refinement) facilitate any kind of access to any form of explicitly described knowledge that is stored in one or more knowledge repositories.

*The Middle (Learning Services) layer* includes services that are built on top of the core services and that transform their output to conceptualizations suitable to the learning environment we

reused among different applications. Upon completion of the KP-Lab platform, tools will range from visual model editors and semantic Wikis to mobile tools like CASS and meeting tools like to-do lists, agendas and argumentation management.

In addition to these layers of services and tools, a comprehensive set of platform services required for the integration and interoperability of KP-Lab tools will be made available across all layers. These include Single Sign-On (SSO), user management (authentication/authorization) and session and state management, and will support communication, security and reliability. Moreover the actions and actors in the plat-

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# The SISINE Project: Developing an E-Learning Platform for Educational Role-Playing Games

by Orazio Miglino

*Role-playing games are commonly used to teach negotiation skills. In traditional practice, learners in a small group act out roles assigned by the trainer. The SISINE project will make it possible to conduct this kind of role-playing game at a distance.*

The SISINE Project, funded by the EU Leonardo Program, has developed an e-learning platform and a teaching methodology with the objective of making it possible to conduct negotiation-type role-playing games at a distance. The teaching methodology exploits a

cific phases of a game, annotate recordings and discuss them with the players.

In June 2007, we began testing SISINE in Poland, Slovakia and Italy. In Poland the experimental group consisted of company sales representa-

## Tools for Teachers

Teachers can write scripts for online multiplayer games or for single player exercises (so-called 'gyms'). In designing a multiplayer game they can choose the roles, goals, bodies and personalities of individual players. Once the game is in progress, they can watch what is going on from any viewpoint, intervene at any moment, send messages to players, or activate special 'events'. When it is over, they can become critics, leading a group discussion and analysing the strategies adopted by the players.

## Tools for Tutors

As well as preparing the scripts for online games and assigning characters to users, there are two other ways in which teachers can intervene in learners' interactions with SISINE. One is to take on the role of one of the characters in the simulation. The other is to act as an invisible stage director. In this second role, teachers can: a) invisibly observe the interactions among players; b) access the players' 'private characteristics'; c) listen in to private messages ('whispers') between players; d) 'broadcast' messages visible to all players; e) exchange private messages with a specific user; and f) activate events, changing the course of the simulation.

## SISINE for Players (Learners)

The first possibility SISINE offers to learners is that of participating in online role-playing games defined by teachers. To access the system, learners use a student version of the SISINE software. Once logged in, they join a 3D graphical environment (see Figure 1) in which they are represented by avatars, and can use these to explore the environment. Players communicate via short texts and various forms of paraverbal and non-verbal communication. For instance, they can control how loud they want to speak (shown by the size of characters used in the bubble cartoons) and in what tone of voice (shown

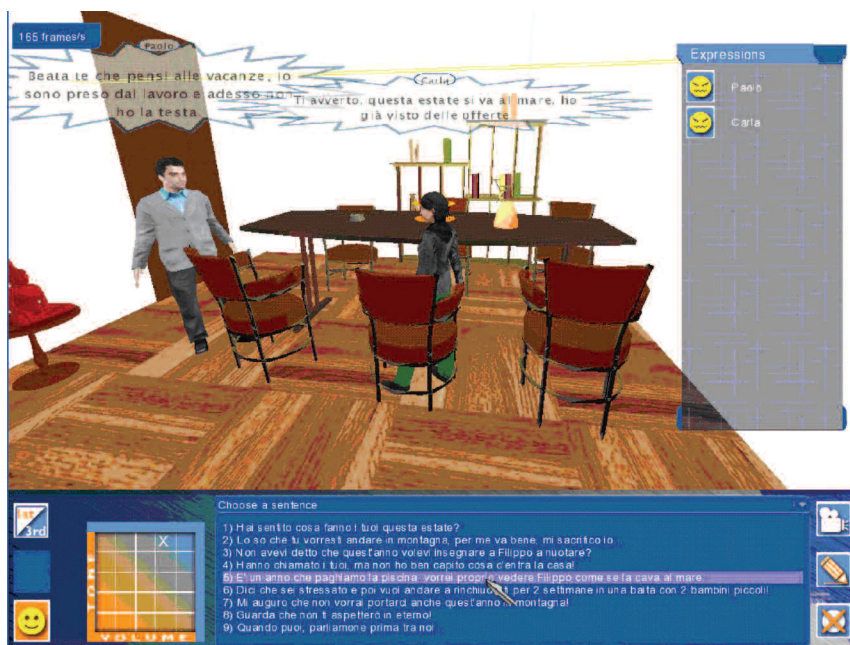


Figure 1: A SISINE role-play game session with two players.

specially developed technology platform allowing a small community of players to communicate, interact and play online. The current beta version supports up to twenty simultaneous players, who are represented by avatars. Communication between players is based on short text messages displayed in bubble cartoons above the avatars' heads, and special commands allow players to control the avatars' movements, gestures and facial expressions. The platform provides the normal functionality expected by players of Multiplayer Online Role-Playing Games (MORPG), as well as additional functions that allow a trainer to set up games, intervene during game play, record spe-

cific phases of a game, annotate recordings and discuss them with the players. In June 2007, we began testing SISINE in Poland, Slovakia and Italy. In Poland the experimental group consisted of company sales representa-



by the shape of the bubble). Another option is using avatars' facial expressions to show warmth, surprise, anger and so on. Players can control avatars' gestures and body movements. They can also 'whisper' messages to each other: these are audible only to the other partner in the conversation, and to the tutor. Finally, they can communicate with the tutor to ask for advice or clarification or to raise any other question that concerns them.

The SISINE team is now working to improve the 'look and feel' of the system and to monitor the trials conducted in Polonia, Slovakia and Italy. SISINE

represents an attempt to use multiplayer game technology applied to an e-learning context. Although the current system is designed primarily to teach negotiating skills we believe that it has a strong potential for use in other domains – in particular in the teaching of strategic and soft skills.

SISINE is a two-year project and is due to finish in October 2007. The SISINE consortium consists of the Institute of Cognitive Sciences and Technologies, Italy (Coordinator); the Artificial Systems group, Université de Paris XII, France; Entertainment Robotics, Denmark; ITTI - Institute of Communica-

tion and Information Technologies, Poland; GlauX, SrL., Italy; TILS Spa, Italy; Mediazioni S.c.a.r.l., Italy; PDCS – Partners for Democratic Change, Slovakia, Slovakia and Xiwrite Srl, Italy.

**Link:**

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## Bringing Together Knowledge Management and E-Learning in Software Engineering: The Software Organization Platform

by Eric Ras and Jörg Rech

*The integration of knowledge management and e-learning has been a frequent topic of discussion in recent years, but the idea has rarely been implemented. The Software Organization Platform (SOP) project is a technology-based approach to bringing the two streams of research closer together. SOP enables software engineers to act as both consumers and producers of information on projects, roles, processes, products, or other learning content. With a focus on the domain of software engineering and by using a semantic Wiki as a technical basis, SOP has recently been made open source.*

As a very knowledge-intensive activity, software engineering strongly relies on an individual's competencies and skills. Short innovation cycles in software engineering and the rapid development of new methods and techniques lead to many learning situations in which new knowledge is required to solve the challenges at hand. Typical approaches include formal courses, seminars, and Web-based training, which are used to familiarize software engineers with new technology.

For the professional workforce however, learning has moved away from strict formal learning types towards more informal and collaborative learning and sharing. This 'Learning 2.0' is characterized by learning at the workplace, interwoven with work processes, related to daily activities, and integrated into available social networks. In addition, the rapid development of semantic Web technology and the availability of collaborative and social software (eg Wikis or blogs) enables the development of

semantic work environments with intelligent assistance and offers new possibilities for the technical support of adaptive individual and organizational learning.

Wikis (which have their origin in software engineering) and blogs have been recognized as beneficial tools for knowledge management and group communication in the corporate 'Enterprise 2.0' world. However, the easy creation, structuring, maintenance, retrieval, dissemination, and understanding of knowledge and experiences still present great challenges.

In the SOP project, we approached these challenges by extending a lightweight knowledge management platform with semantic Web technology and e-learning functionalities. Individual learning in the workplace is supported by a context-aware fusion of previously developed learning content with collaboratively developed documents and experience descriptions from daily work.

The main ideas for SOP emerged from the national project RISE (Reuse In Software Engineering), funded by the German Ministry of Education and Science (BMBF; grant no. 01ISC13D). This research project was concerned with the reuse of software documents in agile software organizations based on ontologies, Wikis and semantic technology. The challenge of RISE was to integrate knowledge management into a software organization in a way that is fun to use and requires only minimal effort. Software developers received assistance in the reuse of requirements, code, information and decisions about the software system they were developing.

With the emergence of semantic Wikis, the ideas and technology developed in RISE were integrated into an internal project at the Fraunhofer Institute for Experimental Software Engineering (IESE), which was named SOP. This project resulted in a technology of the same name – the Software Organization

Platform (SOP) – which is based on a semantic Wiki and is shaped to support software organizations. The first industrial applications focused on the phases of requirements engineering, where SOP demonstrated its usefulness especially for stakeholder participation. Thereafter, SOP was adapted for use

during the whole software lifecycle and for assisting software engineers in managing their observations and experiences. Currently, we are integrating techniques to enhance experience management processes that support the stepwise aggregation of observations and experiences into software patterns.

SOP has been adapted not only to support the documentation of experiences but also to create learning content from existing Wiki content and to provide so-called learning spaces for context-aware workplace learning. A learning space is intended to enhance experience reuse by following a specific learning goal, and is created based on information about the current context (eg, working task, learning preferences, role, product type, competence profile). The learning space is presented by means of dynamically linked Wiki pages within SOP, which is based on a predefined set of didactical templates for experiential learning. The variations due to the individual context are resolved during run time, ie when a learning space has been requested by an engineer. The creation and annotation of learning content is done by means of a metadata editor in the Wiki and by using concepts of a software engineering domain ontology, which is available in the Web Ontology Language (OWL).

Supporting self-reflective processes in a learning environment could enhance the benefit of the activities performed within it, and provide an opportunity for reviewing previous actions and decisions before proceeding to the next activity. As a consequence, professional practice could be improved. An SOP case study showed that by enabling people to document their observations and experiences, reflection which is the prerequisite for learning from experience is stimulated. In addition, a controlled experiment showed that learning spaces improve experience reuse in terms of understandability and applicability to new situations. In addition, they lead to better knowledge acquisition compared to unstructured experience descriptions.

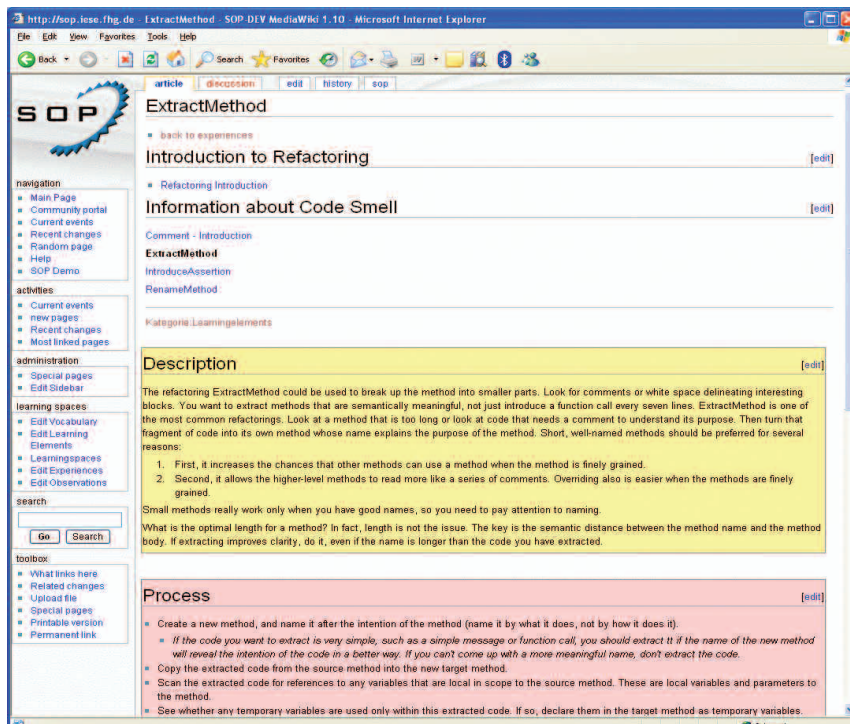
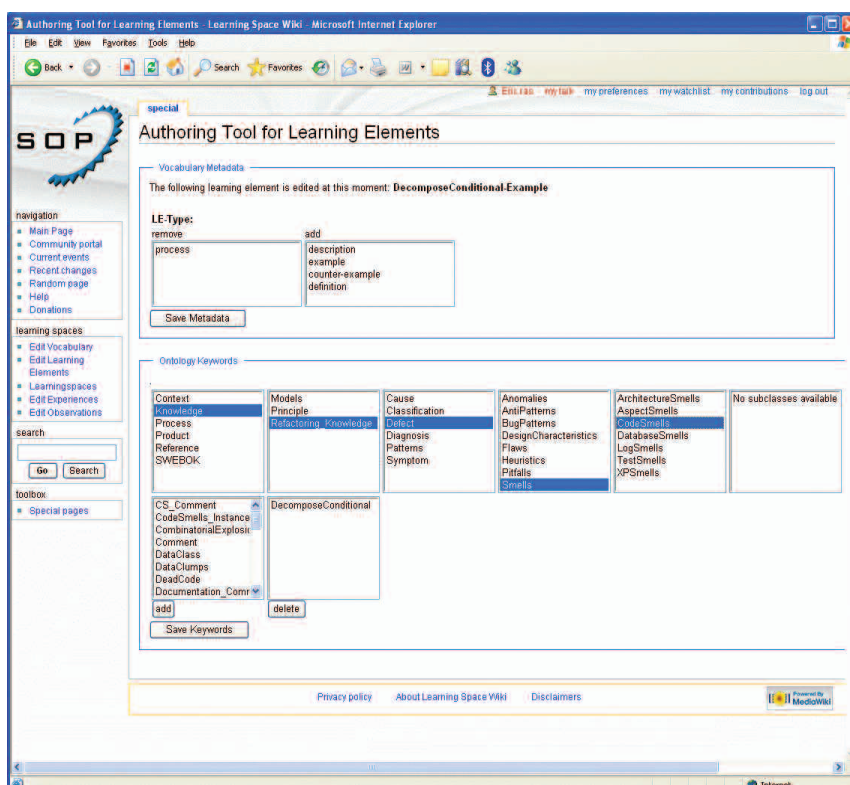


Figure 1: A page of a Learning Space.



Authoring Tool for Easy Creating of Learning Material from Wiki Content.

### Links:

<http://www.sop-world.org>  
<http://sourceforge.net/projects/iese-sop/>  
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# CoPe\_it! – Supporting Incremental Formalization in Collaborative Learning Environments

by Nikos Karacapilidis, Dora Nousia and Manolis Tzagarakis

*CoPe\_it! is a tool of the Web 2.0 era. It complies with collaborative learning principles and practices, and provides members of communities engaged in argumentative discussions and decision-making processes with the appropriate means to collaborate towards the solution of diverse issues. It builds on an incremental formalization approach, which is achieved through the consideration of alternative projections of a collaborative workspace, as well as through mechanisms supporting switches from one projection to another.*

Argumentative collaboration can augment learning in many ways, such as in explicating and sharing individual representations of the problem, maintaining focus on the overall process, maintaining consistency, increasing plausibility and accuracy, and enhancing the group's collective knowledge. Designing software systems that can adequately address the need of users to express, share and reason about knowledge during an argumentative collaboration session has been a major R&D activity for more than twenty years. Technology that supports argumentative collaboration usually provides the means for the structuring and visualization of discussions, the sharing of documents, and user administration. Generally speaking, the intention is to explore argumentation as a way of establishing common ground between diverse stakeholders, understanding positions, surface assumptions and criteria, and collectively constructing consensus.

When engaged in the use of such technology, users must follow a specific formalism; that is, their interaction is regulated by procedures that prescribe and constrain their work. This refers to both the system-supported actions a user may perform, and the system-supported types of argumentative collaboration objects. In many cases, users must fine-tune, align, amend or even completely change their usual way of collaborating in order to be able to exploit the system's features and functionalities. Such formalisms are necessary to allow the system to interpret and reason about human actions, and thereby offer advanced computational services. However, there is much evidence that sophisticated approaches and techniques often result in failure. This is often due to the extra time and effort that users must spend in order to become acquainted with the system, and the associated dis-

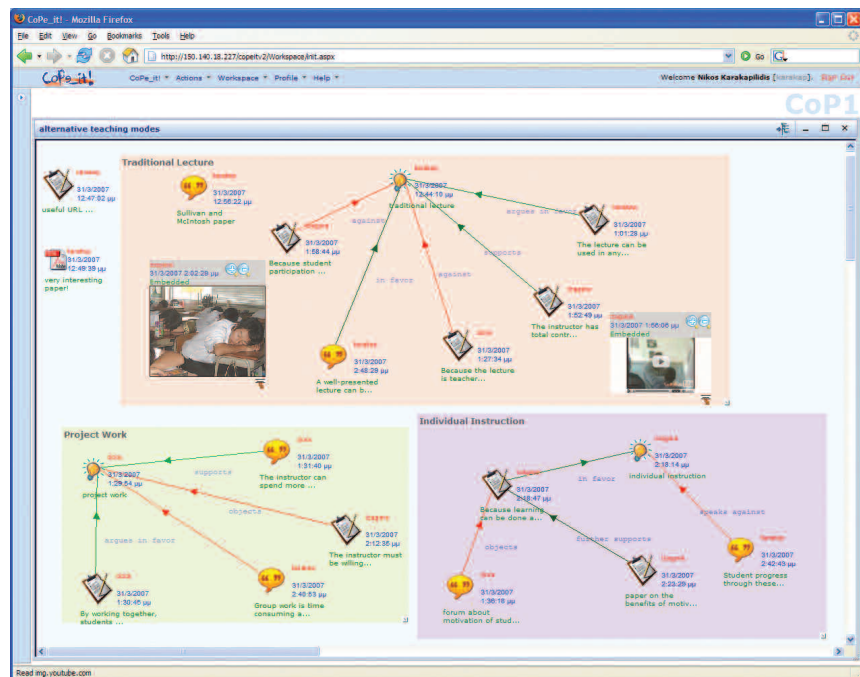


Figure 1: An instance of a collaborative workspace in CoPe\_it! (informal projection).

ruption of their usual workflow. Formal approaches also possess an 'error prone and difficult to correct when done wrong' character.

To address the above issues, CoPe\_it! pays close attention to various visualization and reasoning issues raised in a collaborative learning context. Such a consideration is in line with the 'information triage' process, ie the process of sorting through numerous relevant materials and organizing them to meet the task at hand. CoPe\_it! builds on a conceptual framework in which formality and the level of knowledge structuring during argumentative collaboration is not considered to be a predefined and rigid property, but an adaptable aspect that can be modified to meet the needs of the tasks at hand. By the term formality, we refer to the rules enforced by the system, with which all user actions

must comply. Allowing formality to vary within the collaboration space, 'incremental formalization', ie a stepwise and controlled evolution from a mere collection of individual ideas and resources to the production of highly contextualized and interrelated knowledge artefacts, can be achieved. This evolution is associated with a set of functionalities related to the following:

- collection and sharing of knowledge items
- exploitation of legacy resources
- interrelation and evolution of knowledge items
- informal/semiformal argumentation
- informal/semiformal aggregation of knowledge items
- semantic annotation of knowledge items
- formal exploitation of knowledge items patterns
- formal argumentation and reasoning.



In our approach, 'projections' constitute the vehicle that permits incremental formalization of argumentative collaboration. A projection can be defined as a particular representation of the collaboration space, in which is available a consistent set of abstractions able to solve a particular organizational problem during argumentative collaboration. With the term abstraction, we refer to the particular knowledge items, relationships and actions that are supported through a particular projection, and with which a given problem can be represented, elaborated and - ultimately - solved. CoPe\_it! enables switches to be made from one projection to another, during which the abstractions of a cer-

tain formality level are transformed to those of another formality level. This transformation is rule-based (rules can be defined by users and/or the facilitator of the collaboration and reflect the evolution of a community's collaboration needs). According to our approach, it is up to the community to exploit one or more projections of a collaboration space (according to the needs and expertise of users and/or the overall collaboration context).

Finally, CoPe\_it! reduces the overheads associated with entering information by allowing the reuse of existing documents. Mechanisms for reusing existing knowledge sources, such as e-mail mes-

sages and entries or topics of Web-based forums, have been integrated. This work is carried out within the framework of the IST FP6-2004-028038 PALETTE project, which is partly funded by the EU. The project started on 1st February, 2006 and has a duration of 36 months.

**Link:**  
<http://copeit.cti.gr/>

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## TAO: An Open and Versatile Computer-Based Assessment Platform Based on Semantic Web Technology

by Thibaud Latour and Romain Martin

*Computer-Assisted Testing (CAT) is gaining increasing interest from professional and educational organizations, particularly since the dramatic emergence of the Internet as a privileged communication infrastructure. In a similar fashion to e-learning technology, the generalized use of computers has made possible a wide range of new assessment modalities, as well as widening the range of skills that can be assessed.*

Notwithstanding the dramatic simplification of logistic efforts, significant improvements with respect to classical paper and pencil evaluations have also been made to traceability and automatic data processing at both test design and result analysis times. This is of particular importance where large-scale assessment is concerned. Instant feedback to the subject and advanced adaptive testing techniques are made possible through the use of a computer platform. In addition, CAT makes accessible the efficient and economically viable large-scale measurement of skills that were not accessible using classical testing. Finally, in addition to the strict performance evaluation, the analysis of the strategies used by subjects to solve problems affords very valuable insights to both psychometricians and educational professionals. Effective self-assessment and formative testing are now made widely available on Web-based platforms.

CAT has evolved significantly, from its first stages when tests were direct trans-

positions of paper and pencil tests delivered on standalone machines, to the current use of interactive multimedia content delivered via the Web or through networked computers. During this evolution process, new paradigms have appeared, enabling test standardization, and adaptation to the subject's level of ability, among others. Significant research effort has gone towards the introduction of chronometric and behavioural parameters in the competency evaluation. More advanced testing situations and interaction modes have also been investigated, such as interactive simulations, collaborative tests, multimodal interfaces and complex procedures.

However, even if the use of CAT significantly reduces the effort of test delivery and result exploitation, the production of items and tests, as well as the overall assessment process may remain a potentially costly operation. This is particularly the case for large-scale standardized tests. We are therefore still

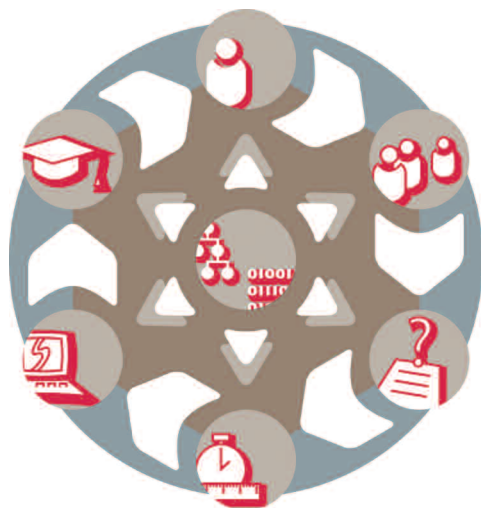
facing a series of challenges regarding the management of the whole process, the creation of a critical mass of items, the reusability of instruments, and the versatility of evaluation instruments among others.

In addition, the consistent coverage of the numerous evaluation needs remains a crucial challenge for new generation platforms. The diversity of these needs can be structured following three main dimensions.

*A chronological dimension:* assessment instruments should be based on frameworks that show chronological continuity across different competency levels, thereby allowing users to adopt a life-long learning perspective.

*A steering level dimension:* assessment usually takes place in a hierarchical structure, with different embedded steering levels going from individuals to entire organisational or international systems. The assessment frameworks





**Figure 1: Schematic illustration of the assessment process; (clockwise from top) subject management, group management, item authoring and banking, test authoring and assembly, testing campaign planning and delivery, and finally result analysis.**

should remain consistent across all levels.

*A competency dimension:* in a rapidly changing world, the range of skills that must be evaluated is also growing. Apart from certain core competencies (reading, mathematical, scientific and ICT literacy), attempts are now being made to create assessment instruments for specific vocational and important non-cognitive competency domains (eg social skills).

Given that most organizations are evolving and therefore have changing evaluation needs, the approach adopted so far for the development of computer-assisted tests (ie on a test-by-test basis focusing on a unique skill set) is no longer viable. Only the platform approach, where the focus is put on the management of the whole assessment process, allows the entire space of assessment needs to be consistently covered. In addition, this platform should rely on advanced technology that ensure adaptability, extensibility, distributivity and versatility.

With these considerations, the University of Luxembourg and the CRP Henri Tudor have initiated an ambitious collaborative R&D programme funded by the Luxembourg Ministry of Culture, Higher Education, and Research. It aims to develop an open, versatile and generic CBA platform that covers the whole space of evaluation needs.

The TAO (French acronym for Testing Assisté par Ordinateur) platform consists in a series of interconnected modules dedicated to the management of subjects, groups, items, tests, planning and results in a peer-to-peer (P2P) net-

work. Each module is a specialization of a more generic kernel application called Generis that was developed in the framework of the project. The specialization consists in adding specific models defining the domains of specialization, several plug-ins providing specific domain-dependent functionalities relying on specific model properties, possibly external applications, and a specific (optional) user graphical interface.

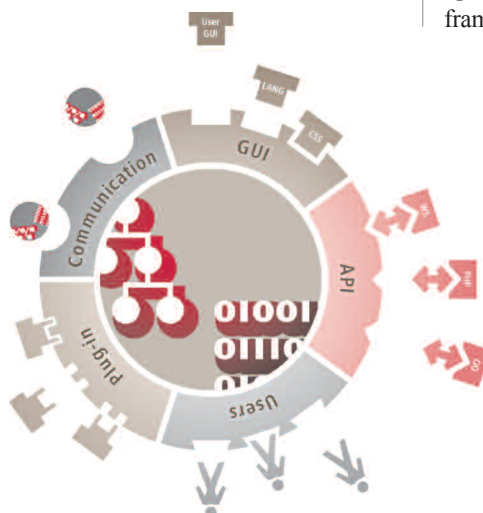
Offering versatility and generality with respect to contexts of use requires a more abstract design of the platform and well-defined extension and specialization mechanisms. Hence, the platform enables users to create their own models of the various CBA domains while ensuring rich exploitation of the metadata produced in reference to these models. Semantic Web technology is particularly suited to this context. It has been used to manage both the CBA process and the user-made characterization of all

the assessment process resources, in their respective domains. This layer is entirely controlled by the user and includes distributed ontology management services (creation, modification, instantiation, sharing of models, reference to distant models, query services on models and metadata, communication protocol etc) based on RDF (Resource Description Framework), RDFS (RDF Schema) and a subset of OWL (Web Ontology Language) standards.

Such architecture enables advanced result analysis functionalities. Indeed, rich correlations can be made between test execution results (scores and behaviours) and any user-defined metadata collected in the entire module network.

Recently we began a very close collaboration on Computer-Based Assessment with the Deutsches Institut für Internationale Pädagogische Forschung, and new rich media have been developed to assess the reading of electronic text literacy in the framework of the PISA 2009 survey. The platform has been successfully used for the last two years in the Luxembourg national school system monitoring programme. Contacts have been established with other European country representatives in order to identify opportunities to use TAO in similar programmes. The platform is also used as a research tool by the University of Bamberg in Germany. As a very general Web-based distributed ontology management tool, Generis has also been used in the FP6-PALETTE project.

The platform is currently in a working prototype stage and is still under development. It is made freely available in the framework of research collaborations.



**Figure 2: Schematic illustration of the Generis distributed ontology management tool.**

#### Link:

<http://www.tao.lu>

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# Context-Based Adaptive and Responsive Authentication

by Gabriele Lenzini and Bob Hulsebosch

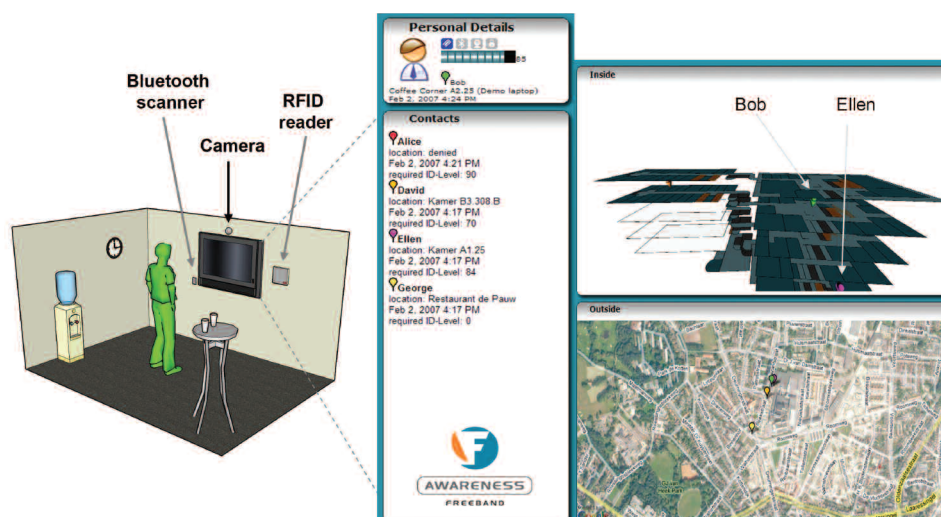
*The Dutch Telematica Instituut has designed adaptive, location-based, and responsive authentication solutions for pervasive, ubiquitous, intelligent environments. This idea is validated with an intelligent coffee corner, where users can see – depending on their identity and authentication tokens – the position of their colleagues on a wall screen.*

Identification and authentication strategies often combine different sources of information to determine the grade of accessibility of a service. The paradigms usually considered in identification and authorization are ‘who a user is’ (eg via biometric measures), ‘what a user knows’ (eg PIN), and ‘what a user has’ (eg smart-phones, PDAs). Traditional security systems are not always suitable for pervasive, ubiquitous intelligent environments, because they are often

tags can be stolen, forgotten or lost, with a consequent risk of identity theft. In controlled environments like buildings, location sensors can be set to detect a wide range of items. The authentication security can be improved by considering the amount of ‘belief’ in the identity of a user standing in a certain location, eg the area from which he/she tries to access a resource. For example, if the mobile phone identifies the user as being on the third floor

visual identification. In this way we propose a responsive authentication, where users can be proactively requested for other, non-contextualized, tokens if the identification and authentication level that emerges is insufficient to grant full access to the resource.

We studied two implementations of ‘belief’. The first is a probability-based implementation that uses a Bayesian algorithm to fuse the location informa-



*Figure 1: (Left) the Intelligent Coffee Corner, including a wall screen and multiple context sensors; (right) the interface shows the user identification and authentication levels, and the resulting list of colleagues and their positions in the building.*

preconfigured to static behaviour, cannot be seamlessly and dynamically adapted to new constraints, and are too intrusive for the user.

Context-aware environments open the possibility of exploiting the automatic detection of users' identity tokens for a new generation of context-aware and proactive services that are less intrusive for users. The grade of access to a service is calculated depending on the user's identification and authentication level which, in turn, is determined by the number and quality of his/her identity tokens as detected by the environment.

Unfortunately, items such as badges, mobile and smart phones, and RFID

(where the service is provided) whilst, at the same time, his/her badge has been detected on the ground floor, the belief in the user standing on the third floor is weak.

We studied the ‘belief’ in identity as a property with which to enhance identification and authentication of users. We calculated identification and authentication levels as a combination of the number and quality of the identity provided by a user, and of the belief we have in that user standing at a certain access point. If the belief is weak, the level calculated is low, and the security mechanism can either grant access with reduced privileges or ask the user for more identification tokens, such as

tion of the sensed identity tokens into a value expressing the probability of the user being in a certain location. The second is an implementation based on trust management that calculates the amount of trust the system places on the user standing in a certain location. Here, sensors are seen as independent recommenders that provide an opinion on a user being in a requested position, depending on what they have perceived in the environment. We obtained a very scalable solution by using Subjective Logics to model opinions and combine them into a trust value.

To validate our proposal we used an intelligent coffee corner in our institute (see Figure 1). The positions of a user's

colleagues are displayed on a wall screen. These colleagues require that their position be shown only if the authentication level of the user is above a certain threshold. In our simulations so far, with the user's tokens moving around, the level changes in accordance with prediction.

Ultimately, the system could learn the user's behaviour, eg based on sensed movement patterns, and use that as a source for identification and subsequent user-friendly access to resources. In order to prevent misuse, any deviation from normal behaviour will trigger an

authentication alert and a request for better authentication from the user. We are now entering the demonstration phase, where the solution will be fully integrated into the coffee corner.

This research is part of the Dutch Freeband Project AWARENESS (context AWARE mobile Networks and ServiceS), which focuses on the design of an infrastructure for context-aware and proactive mobile applications. Our research partners are: Alcatel-Lucent, Ericsson Telecommunicatie, Telematica Instituut, TMSI, Univ. of Twente (CTIT), Roessingh R&D, Yucat and WMC.

#### Links:

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## Turning Web 2.0 Social Software into Collaborative Learning and Knowledge Management Solutions

by Denis Gillet, Chiu Man Yu and Sandy El Helou

*After years of quest by the computer-supported collaborative work community for true user satisfaction, social software and communities of practice turn out to be the enabling frameworks for natural and effective collaborative learning and knowledge management.*

In the framework of the European Integrated Project PALETTE, the École Polytechnique Fédérale de Lausanne (EPFL) is developing the eLogbook Web 2.0 social software (<http://eLogbook.epfl.ch>). The purpose of eLogbook is to support tacit and explicit knowledge management in communities of practice (CoPs). It can be customized by users to serve as an asset management system, a task management system or a discussion platform. It will also be deployed as a general-purpose collaborative workspace for project-based learning activities at the EPFL.

#### Interaction Model

The participatory design approach chosen in PALETTE relies on the full involvement of CoP members and mediators at all the development stages of eLogbook. After a year of implementation, the main result of this process turns out to be the necessity to provide CoPs with mediation solutions that are able to evolve with their interaction modes and practices. As a consequence, eLogbook is built upon the integration of three entities on which users can focus: the Actors, the Activities and the Assets. An actor is any entity capable of initiating an event

in the collaborative environment (eg people, Web services, agents or online devices). An asset is any kind of resource (eg multimedia documents, wiki pages or discussion threads) shared between community actors. An activity is the formalization of a common objective to be achieved by a group of actors (topics, tasks). Events or actions related to these three main entities are governed by Protocols. Figure 1 illustrates the eLogbook 3A (Actors, Activities, Assets) interaction model.

The support of asset management distinguishes eLogbook from general 'one-to-many' forms of social software such as blogs and podcasts. eLogbook enables CoPs to store, share and manage their knowledge and practices in the form of assets. The actors of the CoPs can thus perform 'many-to-many' knowledge sharing. CoPs evolve dynamically by adding, updating or removing 3A entities. eLogbook follows the community evolution by maintaining the relationships between the



Figure 1: The eLogbook 3A interaction model.

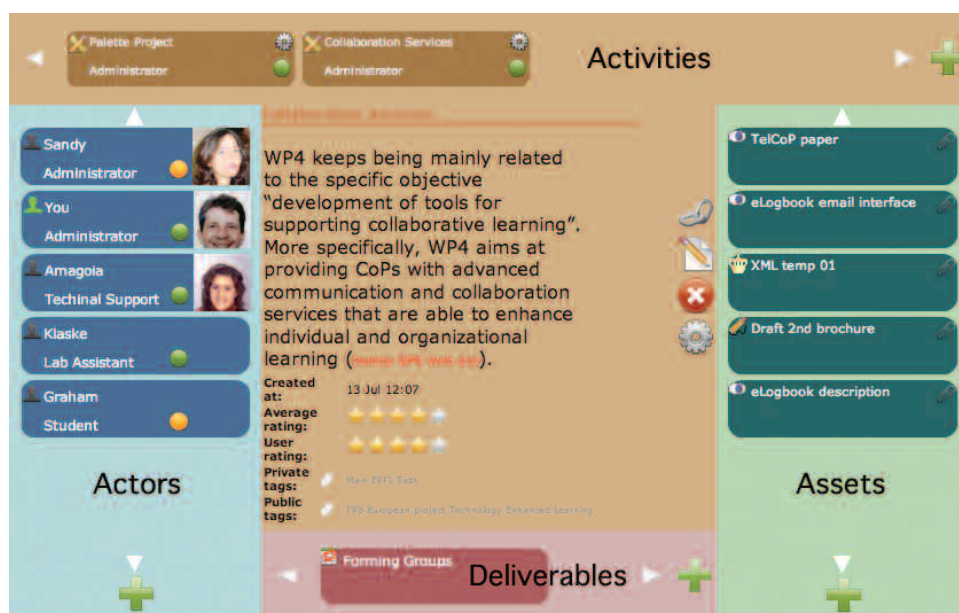


Figure 2: Screenshot of the eLogbook context-sensitive view.

entities. Users can choose to focus on any entities according to their mediation needs. These versatile features contribute significantly to the full appropriation and acceptance of eLogbook as a mediation solution by CoP members.

### Context-Sensitive Interface

The main eLogbook view is context-sensitive and maps the 3A model. Its central region displays a focal element chosen by the user: either one of the 3A entities, or a deliverable. The four surrounding regions (left, top, right, bottom) display respectively the actors, activities, assets and deliverables related to the focal element. They also display the relationships between the focal element and these associated entities, and attach the possible related actions that the current user is allowed to perform. Awareness 'cues' of various types are seamlessly incorporated in every region through the use of symbolic icons, colours and display orders of information. For example, deliverables with earlier deadlines are highlighted in red and appear before on the deliverable list than those with later deadlines.

Figure 2 presents an example of the context-sensitive view where a specific activity is chosen as the focal element. The area surrounding this focal element is populated with the associated and complementary entities, contextually

related. The view embeds different types of awareness that are important to the users. Entity descriptions can be altered using a Wiki-like editor.

### Information Delivery

In addition to Web-based access, eLogbook also supports information delivery through a non-intrusive email-based interface. Thanks to this interface, users can manage their activities, assets and awareness in a ubiquitous way. This alternative lightweight interface first facilitates the appropriation of eLogbook by CoP members. Novice users can in fact share knowledge artefacts and be made aware of ongoing activities through their familiar email client software. Second, it gives easy access to eLogbook with smart phones or PDAs. In the future, eLogbook will support RSS feeds as another means of information delivery for mobile users. The compact format of RSS feeds is particularly useful for mobile users subjected to device constraints. Using authentication, the information of RSS feeds can be personalized for individual users.

Information relevance is of major concern in eLogbook. To avoid excessive interruptions and unnecessary alerts, it is important to dynamically adapt the notification system to the user context, eg device and situation. An adaptive notification filtering system for eLogbook is currently under development.

### Links:

<http://palette.ercim.org/>  
<http://eLogbook.epfl.ch/>

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# Interactive Games in Multi-Device Environments to Enhance the Learning Experience of Museum Visitors

by Giuseppe Ghiani, Fabio Paternò, Carmen Santoro and Davide Spano

*Recent technological advances have led to novel interactive software environments for edutainment, such as museum applications. These environments provide new interaction techniques for guiding visitors and improving their learning experience. We propose a multimodal, multi-device and location-aware museum guide, able to opportunistically exploit large screens when they are nearby the user. Various types of game are supported in addition to the museum and artwork descriptions, including games involving multiple visitors.*

Museums represent an interesting domain of edutainment because of their increasing adoption of a rich variety of digital information and technological resources. This makes them a particularly suitable context in which to experiment with new interaction techniques for guiding visitors. However, such a wealth of information and devices could become a potential source of disorientation for users if not adequately supported.

In this paper, we discuss a solution that provides users with useful information by taking into account the current context of use (user preferences, position, device etc) and then deriving the information that might be judged relevant for them. In particular, we propose a multimodal, multi-device and location-aware museum guide. The guide is able to opportunistically exploit large screens when they are nearby the user. Various types of game are included in addition to descriptions of the museum and artworks, including games involving multiple visitors.

The mobile guide is equipped with an RFID reader, which allows the user's current position to be detected and information on nearby artworks to be received. One active RFID tag is associated with each artwork (or group of neighbouring artworks). Active tags are self-powered and are detectable from many meters, meaning the user need not consciously direct the PDA towards an artwork's tag and can enjoy the visit quite naturally. By taking into account context-dependent information including the current user position, the history of user behaviour, and the device(s) at hand, more personalized and relevant information is provided to the user, resulting in a richer overall experience.

The environment supports a variety of individual games:

- the quiz is composed of multiple-choice questions
- in the associations games users must associate images with words, eg the author of an artwork, or the material of an artwork
- in the details game an enlargement of a small detail of an image is shown, and the player must guess which of the artwork images the detail belongs to
- the chronology game requires the user to order the images of the artworks shown chronologically according to the creation date
- in the hidden word game, the user must guess a word: the number of characters composing the word is shown to help the user
- in the memory game, the user memorizes as many details as possible from an image seen only for a short time, and then must answer a question on that image.

While individual games enable visitors to learn at their own pace, it was also judged that group games would be useful in order to heighten social interaction and stimulate cooperation between visitors. A number of group games have been implemented to date. Users can be organized into teams, and the various players in a team have mutual awareness of each other: coloured circle icons are placed beside representations of different artworks and are associated with various players in a team, so that a player can see which artworks have already been accessed by other players. One of the main features of our solution is to support visit and game applications by exploiting both mobile and stationary devices. The typical scenario involves users freely moving and interacting through the mobile device,

which can also exploit a larger, shared stationary screen (which can be considered a situated display) when the users are nearby. Shared screens connected to stationary systems can increase social interaction and improve user experience, otherwise limited to individual interaction with a mobile device. They also stimulate social interaction and communication with other visitors, though they may not know each other. A larger shared screen extends the functionality of a mobile application, enabling individual games to be presented differently, social game representations to be shared, the positions of the other players in the group to be shown, and also a virtual pre-visit of the entire museum to be experienced.

Each shared display can be in different states:

- **STANDALONE:** the screen has its own input devices (keyboard and mouse) and can be used for a virtual visit of the museum. It can be used by visitors who do not have the PDA guide.
- **SPLIT:** indicates that one visitor has taken control of the display, which shows the name and group of the controller.
- **SEARCH:** the display shows the last artwork accessed by the players of a group and their scores.
- **GAME:** the display shows one individual game.
- **SOCIAL GAME:** the display shows the state of one social game.

Since a shared display has to go through several states, the structure of its layout and some parts of the interface remain unchanged in order to avoid disorientating users. This permanent part of the user interface provides information such as a map of the current section, its

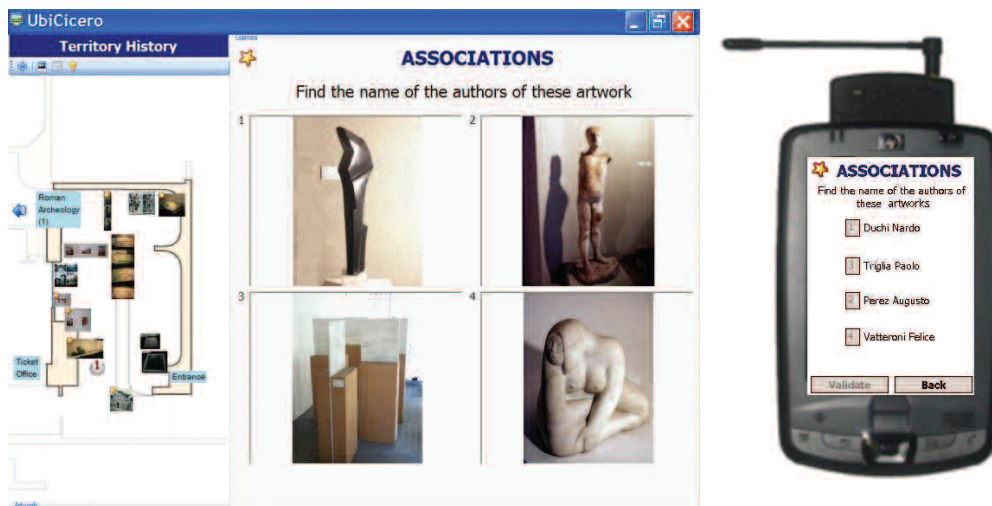


Figure 1: Example of game distributed mode: large screen (left) and PDA (right).

position in the museum, an explanation of the icons used to represent the artworks and the state of the shared enigma. In standalone mode, users can select from three kinds of views of the section map depending on whether icons and/or small photos are used to represent each artwork.

Exploiting the user model data from the connected PDA, the large-screen application generates an interest evaluation for each artwork in the selected room. The user may look up the ratings, which are expressed by 'LED bars' on a scale of 0 to 5. When a user selects an artwork or a game, the layout of the screen interface changes, adapting its focus to magnify the corresponding panel and show the artwork details or the game interface.

The screen changes its state to split when a player selects the connection through the PDA interface. In this case the large screen is used both to show additional information and also to focus the attention of multiple users on a given game, thus exploiting the screen size. When a player is connected to the large screen, its section map view is automatically changed to thumbnails, while the artwork types are shown on the PDA screen. The artwork presentation uses a higher resolution image on the large display, adding description information.

The game representation on the large screen is presented in such a way that it can be shared among visitors and used for discussions. In the distributed representation, the game answer choices are shown only on the PDA interface, while

the question and higher-resolution images are shown on the larger screen (see Figure 1).

The player accessing the large screen can also locate other players. The RFID readers detect the visible tags and their signal strength, allowing the mobile application to locate the user and send the position to the large-screen device.

#### Links:

HIIS Lab: <http://giove.isti.cnr.it>  
or <http://www.isti.cnr.it/ResearchUnits/Labs/hiis-lab/>  
<http://giove.isti.cnr.it/cicero.html>

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## Interactive Educational Play with Augmented Toy Environments

by Steve Hinske and Matthias Lampe

*Enhancing traditional toys with pervasive computing technology yields a mixed-reality platform that combines the best of the real and virtual worlds. Such augmented toy environments can be used in providing multimedia and educational content to children to increase the entertainment value on the one hand and, on the other, to playfully support informal learning.*

Playing is an essential part of childhood: besides being a recreational amusement, it also serves as an important function for the psychological, physiological and social development of a child. Children learn about themselves and the world and people around them; they develop and improve manifold and important skills, such as social competence, problem-solving and creativity.

In contrast to traditional games, computer and video games typically fall far short in providing physical and social challenges. Children sit isolated in front of a computer screen, completely absorbed by virtual worlds and detached from the real world for many hours. Due to the interactive nature of video games however, gameplay itself can offer immersive designs and mental

challenges that constantly adapt to the players' skills, something not possible with traditional games.

Combining these two worlds – the real world and the virtual world, traditional games and interactive computer games – yields an interesting symbiosis that might prove very beneficial for children. The amalgamation of tangible

sensation and virtual content with their own imaginations results in a thrilling entertainment experience for children. Adding virtual reality furthermore enables the integration of interactive educational content that can foster informal learning in a playful way.

Augmented toy environments try to achieve this promising though not trivial goal. By using pervasive computing technology (ie embedded computing devices, miniature sensors and wireless communication technology), traditional play artefacts can be seamlessly connected to virtual content, resulting in a mixed-reality environment that offers many attractive possibilities, especially for educational toys.

We have developed the Augmented Knights' Castle (AKC), an augmented toy environment that enriches children's pretend play by using background music, sound effects and verbal commentary of toys as well as different forms of tactile and visual feedback that react to the children's play (see Figure 1). Moreover, interactive learning experiences can be integrated into the play; for example, teaching songs and poems or providing facts about the Middle Ages.

By using radio frequency identification (RFID) technology, the AKC is able to automatically and unobtrusively identify the play objects. Numerous RFID antennae are invisibly incorporated into the environment and certain play objects (eg the carriage) are equipped with mobile antennae (see Figure 2). Based on the aggregated data gathered by the antennae, the sounds and commentaries are played accordingly (eg the dragon roars when leaving its dungeon). This awareness of location is also exploited



Figure 1: The Augmented Knights' Castle.



Figure 2: An area of the AKC with the technology hidden (left) and disclosed (right).

by the learning component: the king, for example, describes his life in the castle or explains different coats of arms to the children, depending on where he is currently located (see Figure 3).

To provoke further interaction, mobile phones and smart toys (eg a bottle with magic potion that is equipped with an RFID reader and an acceleration sensor) can be integrated into the play set (see Figure 4). Children can use the mobile devices to touch pieces of the augmented toy environment either as part of a learning scenario, a story that then unfolds, or simply as part of free play. While in the case of smart toys the feedback is tactile and auditory, the mobile

phones can also play videos, which is especially beneficial for conveying educational content.

We chose the Playmobil Knights' Castle since it is a realistic image of the medieval world and provides an interesting and exciting environment for children. Additionally, the topic of the Middle Ages offers many anchor points for learning scenarios (eg music, clothing, troubadour literature, chivalry, heraldry, or knights' tournaments). Based on their physical appearance, designated play figures will tell the children about the different aspects of medieval life: the troubadour teaches songs and poems, the blacksmith talks about how



Figure 3: The king invites the child to follow him through different areas and settings of the castle.



Figure 4: The bottle with magic potion is administered to an injured figure (left) and the mobile phone is used to select a figure (right).





weapons and armour are forged, and the alchemist is a master of chemistry and physics. The AKC can even support the learning of foreign languages: by simply changing the language flag, the entire environment will 'speak' to children in another language.

Assuming that the trend of constant miniaturization and steadily increasing sensing and computing power will continue, augmented toy environments like the Augmented Knights' Castle are likely to enter the commercial market in the

near future. By superimposing a virtual layer on traditional toys, such play sets are likely to increase the entertainment value of children's play without neglecting the physical and social experience. In addition, augmented toy environments can provide educational content in a playful and adaptable way with regard to individual preferences and needs. For these reasons, this new form of interactive mixed-reality entertainment may have an influence on how children play that is of similar significance to the emergence of computer games in the 80s.

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## BabyTeach: Using Ambient Facial Interfaces for Interactive Education

by Barnabás Takács

*By merging the power of animation, virtual reality, artificial intelligence and perception to create a novel educational content delivery platform, researchers at the Virtual Human Interface Group of SZTAKI are raising the experience of learning to a new level.*

Ambient Facial Interfaces (AFIs) provide visual, non-verbal feedback via photo-realistic animated faces. They display facial expressions and body language that is reliably recognizable. These high-fidelity digital faces are controlled by the interaction parameters and physical data derived from the state of the user, in our case the student. The output of an AFI system combines these measurements into a single facial expression that is displayed to the user, thereby reacting to their behaviour in a closed-loop manner.

The Virtual Human Interface Group of SZTAKI has created an interactive educational tool called 'BabyTeach', with the goal of demonstrating a new kind of user interface to support education. At the centre of this application there is a virtual baby face that reacts to the students with its elaborate repertoire of facial expressions, mimicking and gestures. These positive or negative expressions help reinforce the educational content. Figure 1 shows a schematic of the structure of our application.

The system runs face recognition algorithms to determine not only if there are users with whom to interact, but also whether it is a single child, a child with an accompanying adult or just a grown-

up standing in front of the system. Based on this information our virtual baby uses different strategies to help learning. This form of non-verbal feedback based on visual perception is supplemented by the tactile subsystem in the form of a touch screen.

Emotional Modulation is a technique that helps transform information into knowledge using emotions as the primary catalyst. The Artificial Emotion Space (AES) algorithm as part of the BabyTeach system is the manifestation of a simple everyday observation: that when we are in a good mood, we are generally more susceptible to information presented in a positive fashion, while when we are sad or down, we prefer things in more subdued manner. This simple notion of empathy presupposes i) recognition of the student's state of mind, and ii) a mechanism to replicate it in the animation domain. As an example, the digital child may exhibit layers of its own emotions that coincide with, react to, or alternatively oppose the student's mood. Via this coupling mechanism the system is capable of provoking emotions in relation to the presented learning material. By associating positive and negative feedback, this emotional modulation algorithm serves as a powerful method

to improve a student's ability to absorb information in general, and educational materials in particular.

The BabyTeach program package builds upon the emotional modulation and non-verbal feedback techniques described above to teach geography and help students of all ages to take tests. The system operates by prompting a series of questions and asking the user to indicate the correct answer by moving a pointer using the mouse. The animated child's face appears in the upper left-hand corner and expresses encouraging or disappointed facial expressions according to the answers. As an example, when the mouse moves toward the proper answer it gently leans forward or nods as a form of acknowledgment. Once a selection is made, immediate feedback regarding the choice is displayed as a smile or tweaking mouth.

Figure 2 demonstrates this process with a test map of Europe. During learning students may make many attempts while the baby's face gently guides them towards the correct answer. Apart from the positive effects of emotional modulation on learning, this application also involves the motor system, thereby further helping to memorize spatial locations. There are multiple levels of

difficulty in which the system offers a greater or lesser degree of context and more or fewer details. The figure shows an average level difficulty, where the borders of countries are shown. Easier tests would contain cities and other landmarks, while the most difficult task involves only the map with no borders drawn. During training, the BabyTeach system also offers cues after a preset number of incorrect answers. In particular, the correct answers will be shown for the student to study and the same question later asked. As a result of the positive facial feedback the student may explore the map by continuously holding the mouse down. The facial feedback of the virtual child will indicate how close he or she is to the country of choice. Of course, when in test mode, no facial feedback is available. However, this mechanism proved to be very successful in helping children to learn geography in a fast and pleasurable manner.

Interaction can occur by touching on-screen visual elements in response to learning exercises, but students may also reach for the virtual baby's face, which upon noticing it is being touched reacts accordingly. To have some fun while learning, the BabyTeach application also lets the students put fingerprint on by changing the colour and properties of the underlying skin. This is shown in Figure 3.

The BabyTeach system also incorporates an advanced multi-user streaming architecture that allows interactive content to be delivered to mobile phones and Internet-based viewers. This feature further opens up the possibility of helping learners of all ages to realize

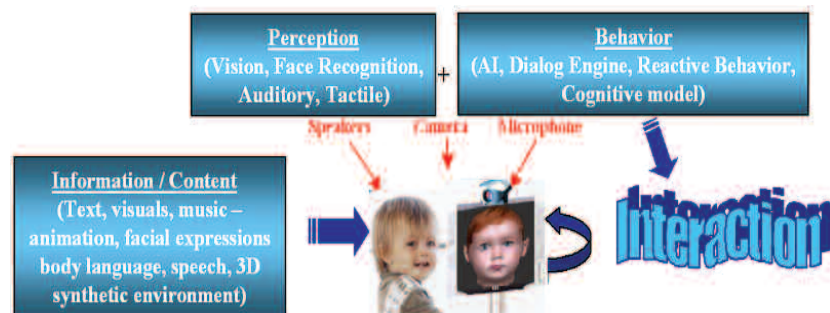


Figure 1: Schemata of the 'BabyTeach' application.

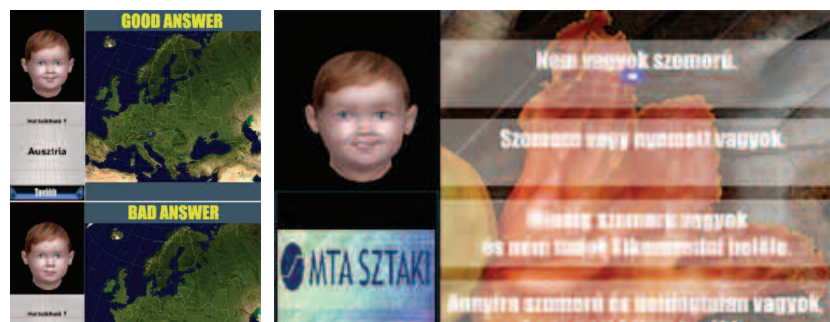


Figure 2: Examples of using the BabyTeach application to teach geography (left), and learning to take multiple-choice tests (right).

their dreams in schools, colleges and universities or from the comfort of their homes.

Our results indicate that the BabyTeach approach provides a novel platform for presenting educational content to learners of all ages. This experimentally evaluated human-centered user interface employs high-fidelity, animated digital faces and advances the state of the art in educational technology. Our solution is based on the mechanisms of closed-loop dialogues and advanced perceptive capabilities with artificial intelligence. We have developed novel algorithms for emotional modulation, a

technique based on the cognitive dynamics of learning and interaction. This helps to increase the efficiency of the learning process while creating positive reinforcement and an interactive experience. The final outcome is the students' increased ability to absorb new information.

#### Link:

<http://www.vhi.sztaki.hu>

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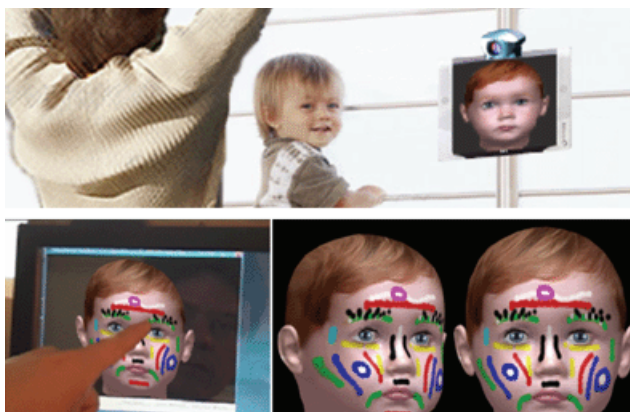


Figure 3: Having fun – the virtual child reacts with facial mimicking, and its face can even be painted when touched.



Figure 4: Our virtual child interacting with the user on a mobile phone.

# Interactive Correction and Recommendation in the Learning of Computer Languages

by Claire Kenny and Claus Pahl

*Active learning and training is an effective form of education. Here we discuss an automated learning and skills training system for database programming that promotes procedural knowledge acquisition. Automated tutoring can provide meaningful feedback, such as correction of student solutions and personalised guidance through recommendations. Automated synchronous feedback and accumulative recommendations based on personalised performance assessment are central features here. At the core of this tutoring system is an error correction component that analyses student input and diagnoses student weaknesses.*

The Interactive Database Learning Environment (IDLE) has been developed for use by undergraduate students in the School of Computing, Dublin City University. The SQL tutor within IDLE provides the student with a range of SQL programming problems. A student answer to a given problem is received and semantically analysed by a correction component, and a guidance and recommendation component then provides suggestions for further study based on an assessment of the student's weaknesses.

SQL is a computer language, and its representation in terms of grammars and syntax trees provides the data and knowledge structures of our system. Correction and recommendation techniques provide feedback for the student based on problem answers and solutions centred on these data structures. The

system's learning content model captures grammar-defined language expressions for answers and solutions in terms of syntax trees to enable analysis. The representation of content knowledge as structured data is the crucial aspect that enables intelligent feedback and interaction between student and system.

An empirical determination and definition of suitable SQL programming problems for the student was completed based on an educator's judgement and experience. For each problem the educator defined an ideal solution, and answers submitted by students are matched against this. The system then focuses on the correction of semantic errors in SQL statements.

Our approach is thus a syntax-driven correction and analysis technique to

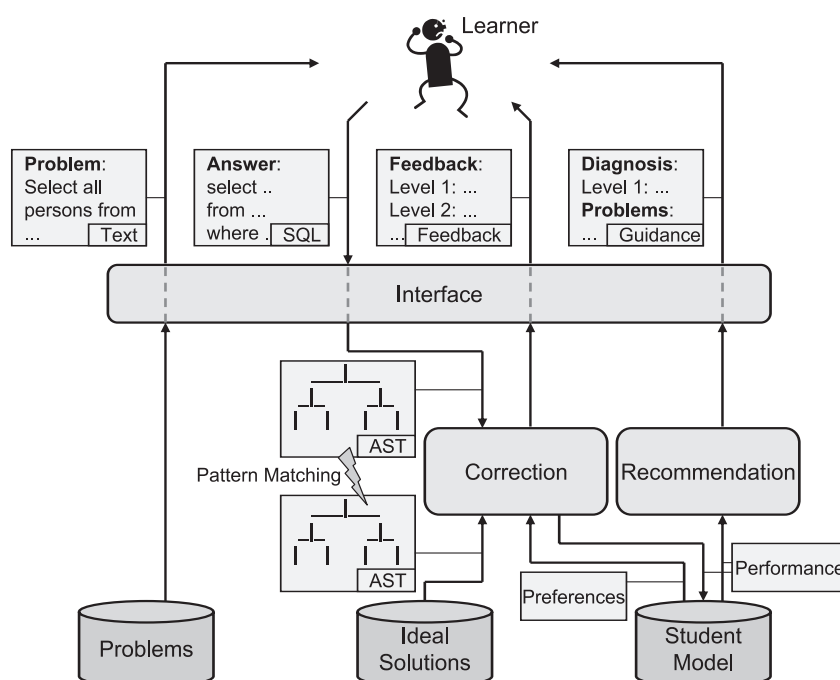
identify and correct errors based on ideal solutions:

- a notion of semantic equivalence on answer representations in terms of abstract syntax trees (AST) identifies correct answers that are not syntactically equal to the ideal solution
- a pattern-matching technique on syntax trees compares the student answer and the ideal solution by matching structural patterns in the two representations, and thus identifies correct and erroneous elements.

A weighted and faceted error categorization scheme allows the classification and explanation of errors. Although semantics is the issue, only an ideal solution in syntactical representation is required as it acts as a semantic solution when employed together with predefined equivalence rules. Abstracting student answers and ideal solutions from concrete syntax and from irrelevant information through patterns provides the basis of the comparison. Pattern matching on the AST structure provides a similarity measure between solution and answer. A two-step procedure is applied: firstly, error determination through semantic equality identification and, secondly, error localization and categorization through inequality-based error determination.

We distinguish two forms of feedback: immediate feedback based on correction that comprises error location, error explanation, hints and correct solutions; and accumulative feedback that comprises a diagnosis of past performance and recommendations for future studies. The recommendation determination has the following features. It is:

- diagnosis-based/personalized, ie derived from individual student performance weaknesses



SQL Tutor – Correction and Recommendation System Architecture.



- accumulated, ie based on weighted and ranked learner assessments,
- filtered, ie presented according to feedback-level preferences and scaffolding principles.

The recommendation algorithm groups errors into categories and calculates the number of errors within each category. A ranked list is made of the number of errors per category and the overall performance is graded based on the weight of each problem and the number and severity of errors made. For each error type, suitable problems are retrieved from a problem repository, thus providing suitable study material.

Feedback is a classical example of scaffolding (a support framework for learning). Correcting, providing feedback and recommendations are part of the scaffolding needed for knowledge-level interactions between student and tutor. Scaffolding can be implemented for computer language learning and training based on both language grammars as the structuring principle that defines learning content, and syntax trees as data structures that capture problem-based knowledge communicated between student and system.

Some difficulties need to be addressed in the implementation of automated

tutoring systems. A system's accuracy and the student's trust level, which is itself affected by accuracy, are important for its success. Designing and implementing a flawless correction method is, however, a challenge. Our experience shows that sufficient accuracy can be achieved for a language of the complexity of SQL.

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## Client-Side Scripting in Blended Learning Environments

by Torsten Ullrich and Dieter W. Fellner

*The computer graphics tutorial CGTutorial was developed by the Institute of Computer Graphics and Knowledge Visualization at Graz University of Technology in Austria. It combines a scripting engine and a development environment with Java-based Web technology. The result is a flexible framework which allows algorithms to be developed and studied without the need to install libraries or set up compiler configurations. Together with already written example scripts, the framework is ready to use. Each example script is a small runnable demonstration application that can be started directly within a browser. Using a scripting engine that interprets Java and JavaScript on a client, the demos can be modified and analysed by the user and then restarted. This combination of scripting engines and Web technology is thus a perfect environment for blended learning scenarios.*

The development of a software solution can be divided into three steps: algorithm design, software design and implementation. Although all the stages belong together, many differences exist between them. During the design of an algorithm, many programming details such as data types are almost unimportant (as long as it is not the design of a numerical algorithm). Books on algorithms therefore frequently use some kind of pseudo-code, which does not distinguish between the many data types. For example, you do not need to know how many bytes are used to store a graph in order to understand Floyd-Warshall's algorithm. The first time these details need to be discussed is during software design. In this phase, data types are important, as good design should be reflected in an implementation and vice versa. Thus, in choosing design tools, the differences between algorithm and software design should be allowed for. Algorithms should not be designed in a sys-

tem programming language (such as C/C++), but rather in a flexible environment that allows the designer to concentrate on concepts rather than on implementation details.

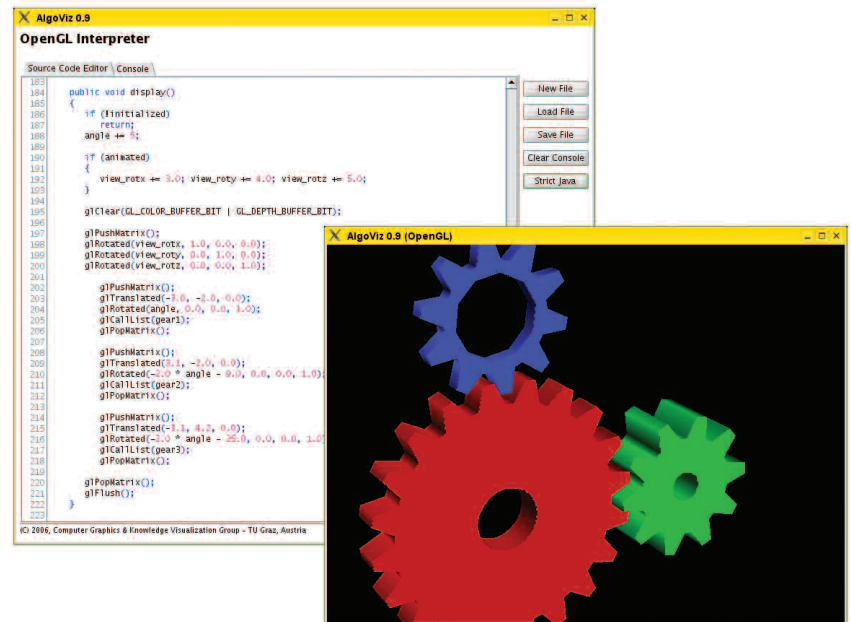
Scripting languages offer just such a flexible environment, and allow algorithms to be designed using rapid prototyping techniques. As John Ousterhout has written in Scripting: Higher Level Programming for the 21st Century (1998), "Scripting languages such as Perl and Tcl represent a very different style of programming than system programming languages such as C or Java. Scripting languages are designed for 'gluing' applications; they use typeless approaches to achieve a higher level of programming and more rapid application development than system programming languages. Increases in computer speed and changes in the application mix are making scripting languages more and more important for applications of the future."

Scripting languages are used to reduce development time in many areas of research and applications; for example, scientific packages such as Matlab are well established in numerics and scientific simulations. They allow the testing of new algorithms in a flexible framework, since the built-in interpreters enable algorithm changes during execution.

The combination of scripting languages with Web technology offers further possibilities. In the context of computer graphics, interplay between forms of technology can be used, for example, in an OpenGL tutorial. Using the scripting framework developed by the Institute of Computer Graphics and Knowledge Visualization at Graz University of Technology, students can start a JavaScript engine implemented in pure Java in a browser. An included editor completes the scripting environment, which can be used to teach computer graphics algorithms. Without the need

to install any libraries (not even OpenGL), students can concentrate on concepts. Very little time is needed to become familiar with the environment. Students can edit predefined OpenGL scripts online, write new script-based applications and start them from within the editor by a simple mouse click.

This framework is a good basis for online tutorials. Included and ready-to-run scripts are able to replace simple applets, and offer many more possibilities and no drawbacks. Furthermore these scripts are the perfect environment in a blended learning setting: demo applications can be started via Web browser and can be modified just-in-time. Such modifications can be made during a lecture or within a drill-and-practice session. Students who use this framework do not have to implement standard program frameworks such as data input routines, matrix multiplications and user interfaces, but instead can concentrate on the algorithms they should learn. In the future, static compiled applets will be transformed into interactive scripts which can be modified online



*The interactive scripting environment integrated in the CGTutorial can be used to teach OpenGL programming. Example scripts can be downloaded from the server and executed on any client with a browser. As scripts are not compiled but interpreted, the source code can be analysed and modified without problems.*

#### Link:

[http://www.cgvis.tugraz.at/CGTutorial/CGTutorial\\_RenderingPipeline.html](http://www.cgvis.tugraz.at/CGTutorial/CGTutorial_RenderingPipeline.html)

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## GVT: Virtual Training in Maintenance Procedures

by Stéphanie Gerbaud, Bruno Arnaldi and Jacques Tisseau

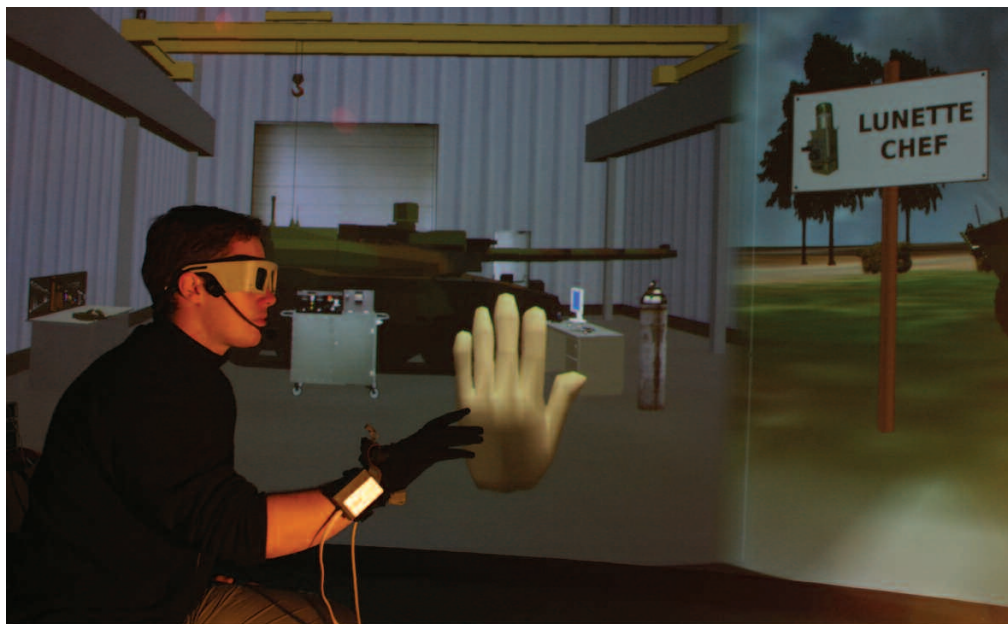
**While the use of real equipment for training in maintenance procedures imposes many constraints, these can be alleviated by the use of virtual reality. The GVT (General Virtual Training) project, developed in a research-industry collaboration, provides a full platform that can be used to build virtual training environments.**

The GVT project was born in 2001, from a research-industry collaboration between three French partners: IRISA and CERV laboratories and Nexter-Group (previously Giat-Industries). This last partner, an important company, was stimulated by the need to train people in the maintenance of sensitive military equipment such as the Leclerc Tank. Virtual reality has many advantages when applied to training: a reduction in cost (eg no need to immobilize equipment), no risk (for trainees as well as for the equipment), control of pedagogical situations, and easy monitoring of the trainees' activity. The GVT project was therefore created to provide a platform upon which virtual environ-

ments for training in maintenance procedures could be built.

GVT is now an operational multi-user application: in a typical training session, a trainer supervises several trainees. Each trainee has a computer, and trains alone on one of the available procedures. The trainees and the trainer don't need to be co-located; they simply need to be on a common network. Furthermore, different hardware configurations are available: from a full immersive room to a laptop or desktop computer. The peripherals used vary with the hardware configuration, but the software remains the same.

GVT has been designed for procedural training, not to test basic technical knowledge. We assume that the trainees already have a certain level of familiarity with the maintenance activity (eg how to press a button or how to use a screw), and do not ask them to simulate such basic actions. Instead, we use some visual metaphors: when the user wants to interact with an object, he simply selects it (using a mouse or a data glove associated with a position sensor) and a contextual menu appears. In this menu, icons represent possible interactions between this object and the user. The trainee can also access a 2D interface in order to change point of view or to ask for help.



**Figure 1:**  
*GVT in an immersive room.*

Trainers have a special interface that enables the supervision of trainees. They can monitor their activities (by viewing progression through the procedure, or the number of errors made), communicate with them, and intervene in the environment (eg to show a specific object, or to trigger a hindering noise).

The actual kernel of our platform is divided into three elements that rely on innovative models proposed by IRISA (LORA and STORM models) and by CERV (for differentiated pedagogy).

### A Behaviour Engine

The virtual world is composed of behavioural objects modelled with STORM (Simulation and Training Object-Relation Model). These objects are endowed with abilities which enable them to interact with other compatible objects. The behaviour engine manages these complex interactions, and is also used to determine what interactions are possible in the environment.

### A Scenario Engine

This engine is used to determine the next steps of the procedure for a trainee, and its state evolves as the trainee achieves certain actions. The scenario is written in the LORA language (Language for Object-Relation Application), the graphical version of which is inspired by Graphcet, and which makes the writing of complex procedures possible.

### A Pedagogical Engine

This engine, employed to assist the trainer, uses the two engines above to decide what the trainee is allowed to do. It adapts its reactions to the trainee and to the pedagogical strategy used. This engine was developed in the CERV laboratory.

These elements have been designed to be generic and reusable. In order to build a virtual environment for training, we must design STORM objects (or reuse existing ones) and specify their abilities, describe the procedure in LORA, and define a pedagogical strategy.

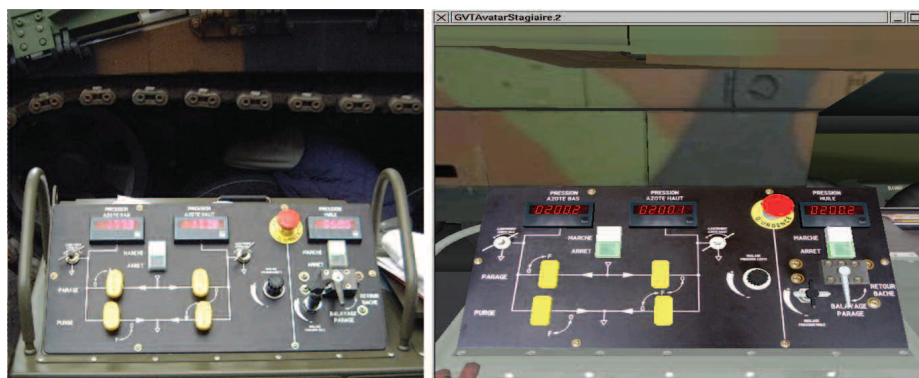
Even though a first release of GVT is under commercialization, research work continues. The next release will provide collaboration opportunities between trainees. Indeed, real users and virtual humans will be able to collaborate to achieve a common procedure. This will allow a trainee to work on a collaborative procedure even if nobody else is available, thanks to virtual humans. Furthermore, these virtual humans could have specific pedagogical roles (eg trouble-maker). The challenge here is to model virtual humans that are incited to follow the procedure while having a certain degree of autonomy.

### Link:

<http://www.gvt-nexter.fr/>

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**Figure 2:** *Transposition of a real control console in the virtual world.*



# OSLab: An Interactive Operating System Laboratory

by Markus Wulff and Torsten Braun

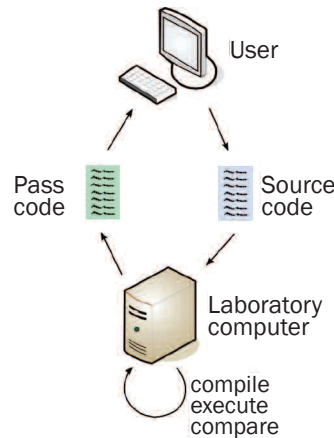
*The Operating System Laboratory (OSLab) project promoted by the Swiss Virtual Campus (SVC) is an online course that will teach the learner about the principles of computer operating systems using a progressive approach and problem-oriented learning. OSLab focuses on a hands-on training experience for the learner.*

Operating systems provide the basic functionality on every computer that allows any type of application software to be run. For computer science students it is crucial to know and understand the principal concepts and mechanisms of operating systems. This understanding helps them to efficiently use programming languages to develop software built on top of the operating system. This also applies to people working in other fields related to information technology, who could benefit greatly from a deeper knowledge of operating system internals.

Instead of teaching operating systems exclusively in traditional classroom lectures, OSLab provides a modular e-learning course with a strong focus on hands-on training. The course currently consists of seven modules that deal with some of the most elementary topics of operating system architecture: process scheduling, inter-process communication, memory management, file systems, distributed file systems, security, device drivers and I/O (input/output). The modular concept of the course allows it to be extended incrementally as needed.

Each course module is divided into four chapters and has the structure shown in Figure 1. Different tools are used to keep track of the learners' progress. Chapter 1 contains an introduction to and information on the goals and content of the module. In Chapter 2 the theoretical part of the module is presented, and it concludes with an intermediate quiz. Chapter 3 contains the necessary instructions for hands-on exercises, including links to the appropriate training computers. The module ends with Chapter 4, in which the learner must solve a final quiz and give general feedback about the experience of completing the module.

Traditional and advanced learning tools and methods are blended to achieve a



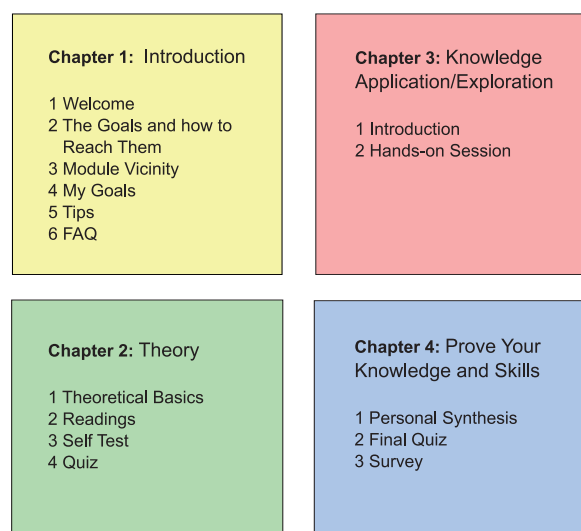
**Figure 1: Structure of an OSLab course module; every module has the same structure and appearance.**

better learning performance. Traditional tools are known from offline courses, while advanced tools take advantage of the new possibilities offered by an online course infrastructure.

The traditional tools consist of the self test, quiz and final quiz. The self test allows learners to determine their knowledge state without being evaluated by the tutor. In the quiz, learners must demonstrate their mastery of the

knowledge acquired in the theory chapter. With the final quiz, learners summarize the results obtained by performing the practical tasks from the hands-on chapter. At each stage, the Interactive Theory window may be used to provide remote access to a Linux computer so that commands and features described in the learning material can be tried out.

The advanced tools consist of a discussion board, a logbook, and special sections like 'My goals', personal synthesis and survey. The discussion forum helps learners exchange knowledge and obtain support from other learners or the tutor(s). The logbook allows learners to keep track of the learning progress and to write down notes for future reference. The discussion and logbook are available throughout the whole module. The 'My Goals' section requires learners to formulate their learning goals based on the introduction, and thereby activates prior knowledge. The personal synthesis helps learners to structure acquired knowledge from the theory and hands-on chapters. It also allows comparison of the initially specified and finally achieved goals. In the survey users are



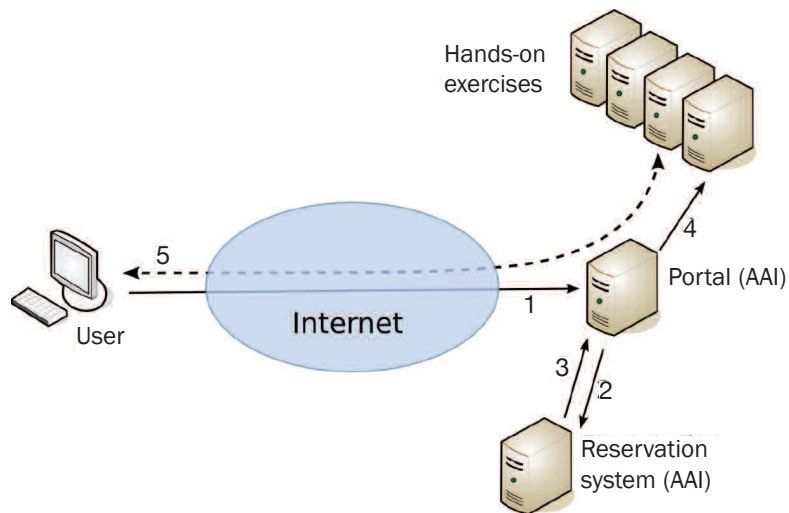
**Figure 2: The hands-on part of the module requires programming exercises to be solved. Users send the source code of the solution to the laboratory computer where it is compiled and executed. The output of the learners' program produced from the test input data is compared to the output of a reference program. In return, the user gets a pass code containing all the information necessary to evaluate the solution.**

asked for feedback to help the tutor and course developers to adapt and improve the learning module.

In addition to the learning modules, a Java applet has been developed in order to present a common user interface for the hands-on exercises. The applet can be adapted to the particular requirements of any given exercise. Learners use this interface to send the solution for the given task to the server, and in return receive a 'pass code' as well as possible log/error messages. At the back-end on the training computer in the laboratory, a compiler and/or simulator is running to compare the presented solution with a given reference solution using the same input data for both. The pass code is delivered to the course tutor, who uses a complementary tool to decode it and review the solution. Figure 2 illustrates this procedure.

This e-learning course will complement traditional lectures, especially in topics for which hands-on training is feasible and a higher rate of learning success and sustainability can be expected. The course and learning modules, which are in themselves closed, allow tutors to choose some or all of the selection of modules and to add new modules in later phases.

The course is being developed and maintained by several universities in Switzerland. The theory pages, which along with the hands-on exercises are currently hosted on a WebCT learning management system, are connected to a distributed authentication and authori-



**Figure 3: Architecture of the hands-on infrastructure.** The laboratory machines are protected by a portal computer. Users send a request for a session to the portal (1). Due to limited resources, a reservation system is used to manage access to the exercise computers (2,3). Only if a free timeslot is available is access to the respective module granted (4) and the session established (5).

zation infrastructure (AAI) and can also be made available to learners from outside the project partner universities. The AAI is coordinated by SWITCH, the Swiss research and education network, and provides single sign-on Web access for all Swiss universities. The architecture of the hands-on infrastructure is shown in Figure 3.

With the cooperation of several institutions, it is possible to share both resources and knowledge. Each partner operates and shares its hands-on training laboratories. Learners profit from a didactically structured and graphically appealing course with interesting interactive and animated learning content and the possibility to individually perform hands-on training around the clock.

Two modules of the OSLab course were successfully tested during the operating systems lecture at the University of Bern in the summer semester of 2007. In the remaining project time until mid-2008, the modules will be completed and tested by students of the partner universities.

#### Links:

<http://www.oslab.ch>  
<http://www.switch.ch/aai/>  
<http://www.virtualcampus.ch>  
<http://www.webct.com>

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## Technology-Enhanced Learning on Industrial Automation Solutions Development

by Emanuele Carpanzano and Andrea Cataldo

**A mechatronics laboratory integrated with an innovative factory has been set up by the Institute of Industrial Technologies and Automation of the Italian Research Council (ITIA-CNR). This infrastructure is strongly exploited for technology-enhanced learning designed for industrial production engineers.**

Education courses on automation usually address the development of a control system by starting from the functional specifications, mathematically modelling the control algorithms, and finally running simplified software sim-

ulations to verify the correctness of the control system. This contrasts with industrial practice, where the design and implementation of an automation system generally goes from the specifications directly to control code imple-

mentation on the specific automation target and to verification in the real industrial plant. The first approach is structured but is not feasible for dealing with the complexity of real-size industrial applications. The second, on the

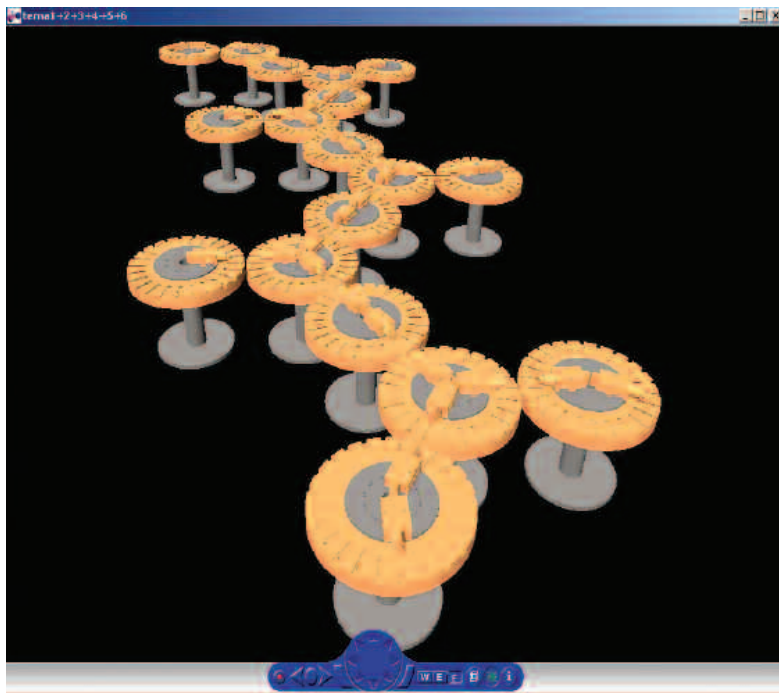


Figure 1: Simulation and graphic animation for verification of control solutions.

other hand, is unstructured and can thus lead to critical problems during the development of automation solutions. The consequences of these problems are high commissioning times and costs, and final solutions with sub-optimal performance. To bridge the gap between such approaches and to fully support the control system engineer during all the steps required to conceive, study, design, implement and verify an industrial automation system, a dedicated mechatronic laboratory integrated with an innovative RTDI factory has been set up by ITIA-CNR. This piece of infrastructure is strongly exploited for technology-enhanced learning of industrial production engineers.

Within education courses the study, design and verification phases of control system development are normally carried out by modelling the control algorithms in specific software environments that also support the numerical simulation for the code verification purposes. The control designer interprets the functional specifications and translates them into mathematical models that are simulated on a PC (see Figure 1). This approach is unsuitable for dealing with large industrial automation systems, because of the excessive complexity of the mathematical models and the computational burden involved in their simulation. Moreover, the implemented control system consists of a for-

malization of the control strategies, using the formalisms available in the simulation environment. Such a control representation, even if tested, cannot be run on the industrial target, and a relevant effort is therefore necessary to translate the control algorithms into the industrial target's control software language. This final step is in any case not strictly necessary in the study of control strategies, so most automation education courses do not go beyond the mod-

elling and verification via simulation of the automation solutions.

In contrast, the implementation of automation systems in industrial practice forces the control designer to implement the control strategies directly into the specific industrial target's control software language, once the functional specifications have been analysed. In such cases, control designers are not able to concentrate on the control strategy concepts because they are not supported by formal modelling languages. As a matter of fact, the control developer mainly executes a software generation effort by translating the specification through simplified proprietary coding rules. Moreover the verification of the control code is normally performed by physically interfacing the control hardware to a dedicated hardware-testing panel composed of potentiometers, thermo-resistors and thermocouples, switches, ammeters and lamps. Each device located on the panel represents a specific sensor and actuator in the industrial plant. The designer involved in the control system verification checks on the hardware-testing panel the correctness of the command given by the controllers and provides the control devices with the right feedback. In this approach both the opportunities for the control designer to learn and thus the effectiveness of the testing are strongly limited, since the real system dynamics are not coherently mod-

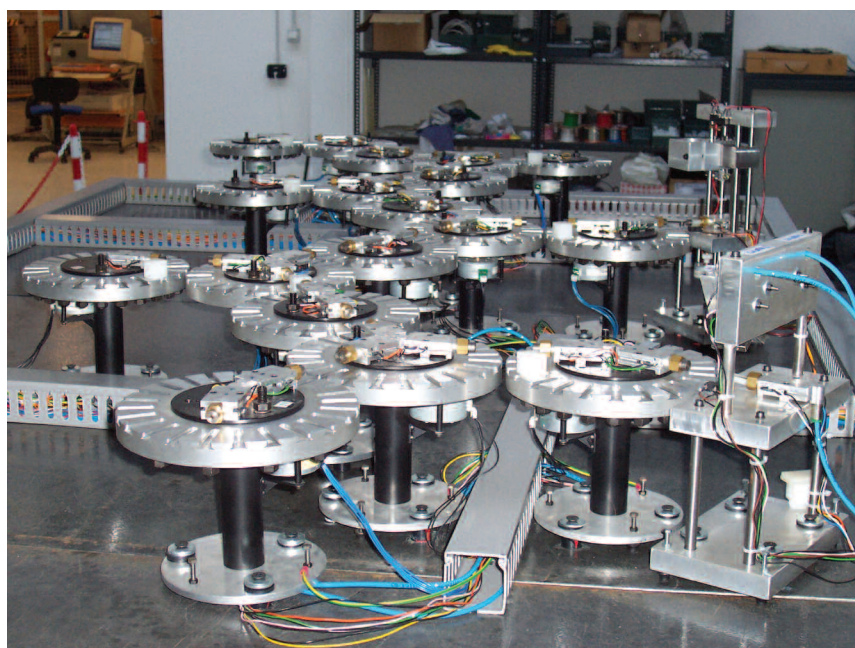


Figure 2: ITIA-CNR small-scale plant.



elled and simulated but only simply and manually reproduced by the control developer.

The ITIA-CNR mechatronic laboratory provides a suitable technology set-up that allows the control designer to experience all the phases of a control system design workflow within a collaborative learning infrastructure. Specifically, different simulation tools may be used to describe both the control strategies and the industrial processes by means of formal models. The verification of the control algorithms may be performed through closed-loop dynamic simulations in the development software environment, so eliminating major specification and design errors in the control algorithms. Afterwards, the translation of these algorithms into the industrial control code running on the target hardware is obtained automatically by selecting a specific target device, which has a tested control code from the functional point of view. Afterwards, the use of a small-scale plant characterized by the same input-output interfaces and discrete time dynamics of the real controlled factory (see Figure 2), allows the

real-time control code to be verified through hardware in the loop simulation methodologies. Such tests allow the operational correctness of the automation software and the proper behaviour of electronic drivers to be verified, which also supports testing actions in non-nominal conditions such as possible failures that could happen on the real plant. Thus, before the control software download on the real industrial control devices, the control engineer is able to improve the control strategies without risking damage to industrial devices.

In this testbed set-up, different types of physical communication technology (ie different fieldbus solutions) may be tested and compared, thus evaluating the best-performing solution for a specific industrial automation need.

The ITIA-CNR automation lab also supports remote usage functionalities by means of Internet-based technology. A truly collaborative learning environment is thus available, in which different users may develop, test and compare automation solutions using the illustrated facilities.

The lab is also directly connected, via a real-time fieldbus, to the ITIA-CNR RTDI shoe factory. This factory, exploited for process and product innovation efforts, is a real production system that manufactures custom-made shoes. Thanks to this connection, the automation solutions developed within the automation lab can be directly applied and tested on the real factory as well.

These features of the ITIA-CNR remote collaborative laboratory and of the RTDI factory infrastructure illustrate the implementation of innovative teaching concepts. Education research and innovation systems have been integrated to provide a new means of technology-enhanced learning in the field of automation.

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## Digital Libraries and Technology-Enhanced Learning: Call 3 Information Days

*The information days to be held in Luxembourg, 17-18 December 2007, address the research community preparing proposals for FP7\* Information and Communication Technologies Call 3, objective 'Digital libraries and technology-enhanced learning'. The event is organised by the European Commission, unit 'Cultural Heritage and Technology Enhanced Learning and aims at helping participants to better understand the work programme and the criteria for the evaluation of proposals, to facilitate sharing of ideas and experiences, and to find partners for project consortia.*

### Technology-Enhanced Learning in FP7

In the first ICT Work Programme under FP7, which defines the research priorities for 2007-2008, technology-enhanced learning research is part of Challenge 4, 'Digital Libraries and Content'. One objective under Challenge 4 is 'Digital libraries and technology-enhanced learning'. The next call for applications for funding of research projects addressing digital libraries and technology-enhanced learning (ICT Call 3) is due to be published around December 2007.

### Research Objectives

Responsive environments for technology-enhanced learning, which:

- accommodate to specific learning needs and contexts (mass individualisation)

- are capable of transforming learning outcomes into knowledge assets
- enhance competence, skills and performance of the learner
- are pedagogically sound

Adaptive and intuitive learning systems, able to:

- identify learner's requirements from intelligently monitoring progress
- exploit learning and cognitive abilities of the learner
- give meaningful advice to both learners and teachers

### Expected impact

- faster and more effective learning, acquisition of knowledge, competences and skills
- unlocking people's and organisations' ability to master knowledge and apply it
- increased knowledge worker productivity
- more efficient organisational learning processes

### More information:

[http://cordis.europa.eu/fp7/ict/telearn-digicult/telearn\\_en.html](http://cordis.europa.eu/fp7/ict/telearn-digicult/telearn_en.html)

\*The Seventh Framework Programme for research and technological development (FP7) is the European Union's chief instrument for funding research over the period 2007 to 2013.

Source: Community Research & Development Information Service

# Bayesian Algorithms for Indoor Radio Localization

by Monica Nicoli and Vittorio Rampa

*Localization of moving users or terminals (MTs) is one of the hottest topics in mobile radio/network research and development. User localization may be achieved by satellites (eg using the GPS or the forthcoming GALILEO satellite system) or radio. While in the first case one or more additional devices must be embedded in the user terminal, thus making it more complex and expensive, the latter scenario requires no additional devices since only radio/network services are employed. Radio-assisted localization is the only method suitable in indoor or urban canyon scenarios where satellite signals are not available.*

In wireless systems, MT localization is achieved by estimating the radio propagation parameters related to the MT location. These are obtained by exchanging radio signals with  $N$  fixed base stations or access points (APs), which are placed in known positions. Typical propagation parameters are: times of arrival (TOA), time differences of arrival (TDOA), angles of arrival (AOA), and received signal strength (RSS). The relationship between these parameters and the MT position can be given either by analytical models or through real field measurements. These measurements are exploited to evaluate the MT-AP distances: this step is called ranging. Localization is then obtained by tri-lateration (ie  $N=3$ ) using only the minimum number of APs, or by multi-lateration (ie  $N>3$ ) to increase the method robustness.

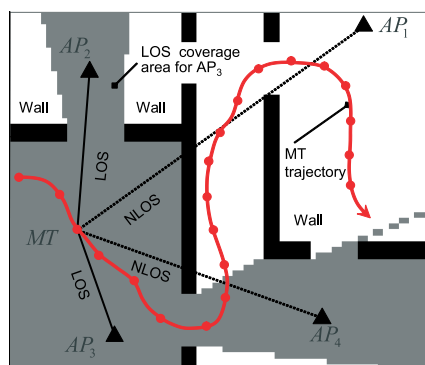
The localization steps may be computed by the MT device: this scheme is known as terminal-based localization. No wireless network modifications are required but more complex hardware is

needed at the terminal side. In contrast, network-based localization is performed when the localization algorithm is carried out by the radio network itself. Usually this is obtained by using specialized synchronous network access points. This localization scheme is more complex than the previous one and is usually employed in cellular radio systems.

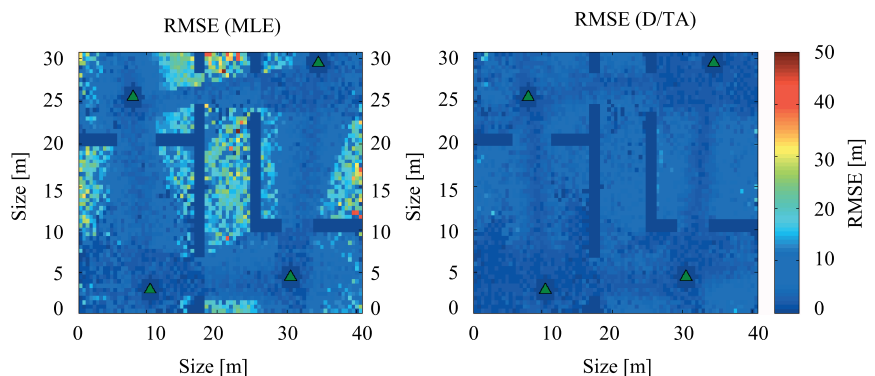
Positioning accuracy is the main benchmark for the localization algorithms. False localizations often arise in ranging methods due to errors in the MT-AP ranging step. These unwanted effects are due to parameter estimation errors, over-simplified assumptions about the propagation environment, multipath effects and non-line-of-sight (NLOS) conditions. In fact, the MT may not be visible from the AP. Moreover, in indoor radio localization scenarios characterized by dense multipath and/or NLOS conditions, these errors become more critical, since ranging leads to apparent or biased distances due to propagation over secondary paths. For

these reasons, a localization approach that takes into account mixed LOS/NLOS conditions is mandatory. The most common techniques consist in exploiting redundant measurements (large  $N$ ), merging different measurement types with data fusion techniques, combining analytical models with maps of measurements, or using Bayesian methods to estimate the whole MT trajectory rather than estimating one position at a time.

In our work, we considered a radio network with  $N=3$  APs covering the area within which the MT must be localized. In principle, accurate ranging could be obtained by estimating the TOA or TDOA from the received signals. However, dense multipath and large delay spreading, often found in indoor environments, strongly reduce the signal resolution during the ranging step. In addition, multiuser access interference (MAI), introduces further signal degradation. In these conditions, the high resolution (ie sampling rate) required by the TOA or TDOA-based methods does



**Figure 1:** Indoor layout used for simulations. Black dotted (solid) lines show NLOS (LOS) conditions between the specified AP and the MT at a given instant in time. Red dots indicate different MT positions (ie MT trajectory).



**Figure 2:** Algorithm RMSE performance comparison. The D/TA algorithm can recover from severe false localization errors introduced by the MLE method and caused by mixed LOS/NLOS conditions (eg in the central alley).

not necessarily imply high-resolution ranging results, due to the rich multipath environment that prevents an accurate estimation of the first arrival delay.

To improve the localization accuracy, we propose to track the MT position from the RSS-delay profile measurements rather than from the ranging steps. The proposed localization scheme exploits a Bayesian grid-based tracking algorithm. This method estimates the MT location at a given instant by using all the signals measured up to that instant along the MT trajectory over the  $N$  links (see Figure 1). It may be the core algorithm for both network-based and terminal-based localization schemes.

The proposed algorithm is the Detection/Tracking Algorithm (D/TA), based on a Hidden Markov Model (HMM). D/TA is a real-time forward-only algorithm that, given all the signals collected up to the current time instant, maximizes the a posteriori probability of the hidden state by using lateral continuity information about the MT trajectory.

The HMM state is defined as the set of the MT position and the LOS/NLOS conditions with respect to all the  $N$  MT-AP links. Local-only algorithms (eg maximum likelihood estimation - MLE) introduce tracking errors since they do not take into consideration the physical constraints due to the MT trajectory. In contrast, the D/TA algorithm is based on an HMM Bayesian approach that models the MT moving capabilities and the sight conditions. In fact, to reduce tracking errors in mixed LOS/NLOS scenarios, the proposed D/TA algorithm jointly estimates both position and sight conditions of the MT. Finally, the power delay profiles for the signals received over the  $N$  radio links are used to track the most likely state sequence. It is worth noticing that this HMM-based approach does not depend on linearization or Gaussian assumptions.

Figure 1 illustrates the network layout used for simulations, while Figure 2 demonstrates how the D/TA method outperforms local-only algorithms like MLE. A faster implementation of the

proposed algorithm that uses the Particle Filter approach has been presented. More details are given in the project Web site.

This research activity has been developed within the FIRB Vicom (Virtual Immersive COMmunication) project.

#### Links:

Localization in wireless networks:  
[http://www.dei.polimi.it/ricerca/sezioni/progetti/dettaglio.php?idlang=eng&id\\_progetto=83](http://www.dei.polimi.it/ricerca/sezioni/progetti/dettaglio.php?idlang=eng&id_progetto=83)

<http://www.elet.polimi.it/dsp/tlc/position.htm>

<http://www.vicom-project.it/>

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## More Efficient CT Scans with Discrete Mathematics

by Bram Vermeer

*CT scans are set to become far more efficient. That is the outcome of a study conducted at CWI by Joost Batenburg, who obtained his PhD in 2006 with a thesis on algorithms for computer tomography. The results of Batenburg's research offer new prospects for medical diagnosis, but are also of interest to diamond cutters. It also allowed him to capture images of individual atoms in small crystals from electron microscopy data.*

A CT scan consists of hundreds of X-ray images, each of which is made at a slightly different angle. Individually, these are little more than two-dimensional images, but together they provide enough data to reconstruct a three-dimensional image. Over the years, various algorithms have been developed for the computation of such three-dimensional images. The more X-ray images used to reconstruct the three-dimensional image, the more detailed it will be. The opposite also applies. If too few images are available, only a vague image is produced.

Existing reconstruction algorithms for tomography produce unsatisfactory results if fewer than ten X-ray images are available. However, this problem

can be solved if the reconstruction process incorporates additional knowledge. In industry, for example, many products are scanned to check whether they contain hidden cracks or cavities. In such instances, not all greyscale values have to be computed to produce a 3-D image. Black and white are sufficient. The material is either present or absent. This type of reconstruction, using only a limited range of greys, is known as 'discrete tomography'.

#### Sharper Reconstruction with fewer Images

Algorithms for discrete tomography produce much sharper 3-D reconstruction using fewer X-ray images, because a priori information is incorporated into

the computation. However, this does not necessarily imply that such images can be computed more quickly. Reconstructions of images based on a continuum of greyscale values are easier to compute than when only a limited number of such values are available. When Joost Batenburg started his research, reconstruction algorithms in discrete tomography were limited to images no bigger than 50 by 50 pixels. That is rather small, in this age of megapixels. In practice, it was impossible to make use of a priori information to produce sharper images. It is therefore customary to simply produce extra images during CT scans to ensure sharper images, even though this results in higher radiation levels and higher costs.



In collaboration with Robert Tijdeman (Universiteit Leiden, the Netherlands) and Herman te Riele (CWI), Joost Batenburg devised a new computation procedure. The trick is to ensure that the X-ray images are not all evaluated simultaneously. Instead, the computer evaluates the images in pairs. Based on just two X-ray images, it produces a rough three-dimensional reconstruction. This rough image is subsequently used as prior information for the evaluation of the next pair of images. In this way, the computer repeatedly reconstructs a three-dimensional image using two X-ray images. As computation progresses, the reconstruction becomes more precise. Even very tiny, single-pixel details are eventually reconstructed with great accuracy.

Because only two images are used in each instance, the required computation is much less complex. In fact, the computation has much in common with the so-called minimum-cost flow problem, a notorious computational challenge in the field of operations research. The problem in question is all about calculating the most efficient way of pumping a fluid through a flow network. This problem has been studied extensively, resulting in a wide range of efficient algorithms.

#### Megapixel Scan

Batenburg's computer program required the integration of knowledge from three diverse fields – mathematics, computer science and physics. Fortunately, Batenburg graduated cum laude in two of



*Figure 1: A diamond. With discrete tomography fewer scans are needed to detect flaws, so more of each stone can be retained.*

*Source: Shutterstock.*

these fields. Insight into coding theory was required to adjust for noisy data; insight into number theory and numerical mathematics was required for the systems of linear equations with natural numbers; and he also applied knowledge from the fields of evolutionary algorithms and operations research.

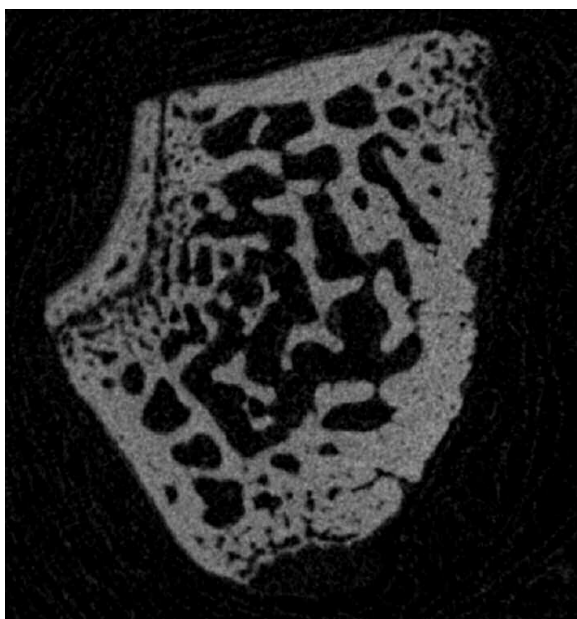
The program Batenburg developed produces images of about one megapixel. That is large enough to ensure the feasibility of this approach, which was subsequently used to study osteoporosis in mice, in collaboration with the University of Antwerp. In bone scans of this kind, only a limited range of greyscale

values are required, because osteoporosis causes cavities in the bones: in other words, bone material is either present or absent.

Another application is computing images of individual atoms in nanocrystals: miniscule crystals consisting of several hundred atoms, which are used in LEDs and catalysts. Here, electron microscopy images are used instead of X-rays. With these images the production methods can be improved. The enhanced CT scans can also be used in the diamond industry, since having the ability to detect flaws in a stone enables the cutter to reduce wastage. With discrete tomography fewer x-ray images are needed, leading to increased efficiency and decreased cost.

These are but a few of the many possibilities. Batenburg's research team now aims to develop a stronger theoretical foundation for the newly developed algorithms. They are currently considering generalizations of the algorithm to other areas of interest, such as the reconstruction of images using more than two greyscale values, or the reconstruction of three-dimensional images. Other potential areas of application include medical imaging and tomography of industrial objects, such as nanosize electronics and critical parts for aircraft.

Joost Batenburg's research was awarded the Philips Mathematics Prize for PhD students in March 2006, and the C. J. Kok Prize of the Universiteit Leiden in January 2007.



*Figure 2: Discrete tomography improves CT scans. The image of this mouse thighbone can be approximated with only two grey levels, making it a perfect application for discrete tomography. Courtesy of Skyscan, Belgium.*

#### Link:

<http://visielab.ua.ac.be/staff/batenburg/>

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# Quantum Information Processing

by Bram Vermeer and Harry Buhrman

*Work on quantum entanglement at CWI gives new insight in the non-locality of Nature. There is also a surprising connection to fault tolerant computing and the feasibility of quantum computers.*

In 1935 Einstein, Podolsky, and Rosen devised a famous thought experiment. In quantum mechanics, it is possible to construct two particles that are strongly coupled. Suppose that Alice has one particle in Amsterdam and Bob has the other in New York. When Alice measures her particle she will observe a random outcome 0 or 1, each with equal probability. The same is true for Bob. However, Alice and Bob always obtain the same value. Such particles are called entangled. It seems that the outcome of Alice's measurement instantaneously influences Bob's one. However, this should not be possible since nothing goes faster than the speed of light.

In order to explain this apparent non-local phenomenon one tried to come up with local hidden variable models. If the outcome of Alice's and Bob's measurement was already known at the time the two entangled particles were created, then their correlation would not require instantaneous communication.

It was John Bell who in 1964 came up with the description of a clever experiment that would shed more light on the situation. He created a game and showed that if quantum mechanics is non-local, then Alice and Bob could win this with higher probability than what is classically possible. In the early 1980's Alain Aspect and his group (Orsay, France) demonstrated that Nature is indeed non-local and there is no local hidden variable model that can explain it.

## Quantum Computing and Entanglement

Quantum computing groups at CWI and in North-America addressed in the late 1990's the non-locality issue in more operational terms. In quantum mechanics entangled particles can not be used for communication. This non-signalling property is important since it would otherwise be in direct conflict with Einstein's theory of relativity. But our research groups showed that certain distributed computation tasks can be solved with less communication when one makes use of entanglement.

Take for example the agenda problem: Alice and Bob want to make an appointment and need to know the free slots in each others agenda. If Alice and Bob have a quantum computer and share entangled particles, they can agree with significantly less communication than what is classically possible. For certain problems, there is even an exponential saving in communication

He showed that if Nature allowed the CHSH game to be won with 100 percent, then every distributed communication task would become trivial, and would only require a single bit.

Harry Buhrman (CWI and University of Amsterdam), Falk Unger (CWI), and groups in Montreal and Bristol examined the case when Nature would allow



*Keep communication simple. How much information does Bob have to send to Alice in order to fix a date?*

(although savings are not always possible). In certain cases entanglement can be used to communicate more efficiently, but it cannot be used to replace communication altogether.

## Beyond Quantum Mechanics

To understand the non-local aspect of Nature better, Popescu and Rohrlich investigated in the 1990s in more detail a non-locality game, called the CHSH game. This game can be won with probability roughly 85 percent when making use of entanglement whereas without, it can only be won 75 percent of the time. They showed that this game can in principle be won 100 percent of the time without violating the non-signalling primitive. They raised the question: "Why is Nature not more non-local?"

A partial answer was given by Wim van Dam, at the time PhD student at CWI.

this game to be won with a probability between 85 percent – the quantum mechanical bound – and 100 percent – the ideal Popescu-Rohrlich bound. Their findings – reported in Phys. Rev. Letters and reviewed in Nature Physics – show something remarkable. There is a sharp threshold with respect to the probability to win the CHSH game and communication required for every distributed task. They show that when the game is won with a probability around 90 percent still every distributed computation problem can be solved with one single bit of communication. On the other hand, at 85 percent many problems require a lot of communication. These results indicate a different reason why Nature is not more non-local than at least 90 percent, since this would render communication tasks trivial. It is a fascinating open problem whether the true threshold of trivial

communication lies at the quantum mechanical bound of 85 percent, or higher.

#### The Feasibility of a Quantum Computer

These results have intriguing consequences for the efficiency of computers. The high-speed computers that are set to make their entry in the coming years will inevitably be prone to errors. Computer science has a solution for this problem in the form of fault-tolerant algorithms. The components that carry out these adjustments are also susceptible to error. This implies that there are limits to the degree of error that can be rectified in this manner. This threshold

is important when it comes to quantum computers since they will inevitably be prone to error. They should therefore be designed with fault-tolerance in mind. But this raises the question: at what level of error is quantum computing impossible?

Buhrman and fellow researchers have discovered a surprising connection between fault-tolerant computation and the results on non-locality. By exploiting this connection they have constructed a new upper bound for the error threshold, above which quantum computers would be unable to function. The exact bound of this error threshold is

important to establish since it shows exactly how reliable the components of a quantum computer must be in order to function properly. Currently the best known bound for the error threshold is still far away from the errors observed during experiments in the laboratories around the world.

#### Link:

<http://www.cwi.nl/ins4>

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## Mathematical Models for the Conservation of Cultural Heritage

by Fabrizio Clarelli, Antonio Fasano, and Roberto Natalini

*Air pollution is one of the most serious causes of degradation in carbonate stone, which in the form of marble, limestone and similar materials comprises some of the most important monuments and artefacts in the world. Mathematicians have now begun to model the degradation problem in order to assist in the protection and restoration of this stone. This paper presents a free boundary model, which describes the growth of a gypsum crust on the surface of marble monuments under  $\text{SO}_2$  aggression, and quantifies the influence of environmental factors such as pollutant concentration, humidity and temperature.*

The list of great monuments and frescoes destroyed or seriously damaged by negligence or criminal action is dramatically increasing; sadly, some of the most lethal attacks have been from air pollution. Although pollution in European urban areas has decreased considerably in recent years, pollutants such as sulfur dioxide ( $\text{SO}_2$ ) and nitrogen oxides ( $\text{NO}_x$ ) are still present and active.  $\text{SO}_2$  is the most important factor in the chemical deterioration of calcareous stones. It reacts with calcium carbonate to produce an external layer of gypsum (calcium sulfate) that eventually exfoliates (see Figures 1 and 2). The rate at which this process occurs depends greatly on the nature of the stone and the presence of moisture. Since the stone is porous, condensation of moisture may occur in pores deep inside the material. The reactivity of the material to the pollutant therefore becomes the critical factor.

Despite intense experimental research by conservation scientists, further studies are necessary in order to provide a predictive tool. Chemistry, of course, has the

most to reveal about the causes of stone degradation. However, mathematical modelling can lead us to a better understanding of the relative importance of the simultaneous processes involved. Models can help to predict the evolution of phenomena and their dependence on seasonal variations in basic physical quantities (eg air pressure, temperature, moisture content, rainfall and – naturally –

pollutant concentration). As a consequence, a mathematical model can be used as the basis for determining an optimal strategy for restoration or even prevention.

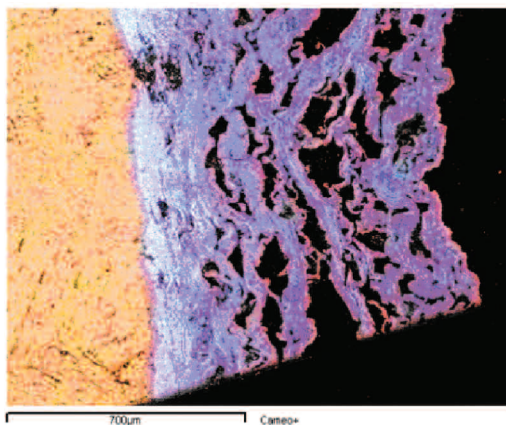
These problems are currently being considered by groups working at the Istituto per le Applicazioni del Calcolo 'M. Picone' (IAC-CNR) in Rome, in collaboration with a group from the Department of Mathematics at the University of Florence. Using an initially simplified approach, differential models of the evolution of the gypsum crust have been proposed, and then validated against laboratory experiments.

More recently, we have developed a more realistic free-boundary model, and investigated it in detail (see link below). This model includes important features such as swelling and relative humidity. These two factors have a strong influence on the evolution of sulfation and therefore demand specific consideration. The transformation of marble into gypsum is accompanied by a volume change, which yields quite a consistent

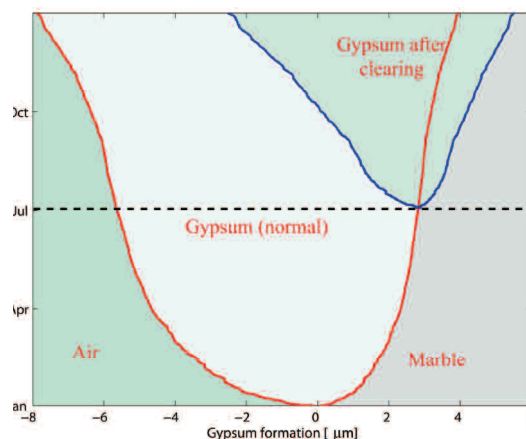


*Figure 1: Head of a rain god, carved on the Antonina column in Rome. Erosion and crusts have been caused by  $\text{SO}_2$  pollution.*





**Figure 2: SEM-EDS map of the chemical elements on a marble surface exposed for 144 hours to  $\text{SO}_2$  aggression (calcium carbonate: on the left; gypsum: on the right). Data obtained in a laboratory test (courtesy of M.L. Santarelli of CiSTEC, Rome).**



**Figure 3: Simulation of the evolution in time (over one year) of gypsum formation, with clearing after six months (blue line) and without clearing (red line). We used real data taken at Villa Ada in Rome (courtesy of Arpalazio, Agenzia Regionale per la Protezione Ambientale).**

swelling. Although determining the swelling rate is not easy, it is reasonable to say that the volume of the gypsum produced during the transformation is two or three times the volume of pristine marble. Concerning humidity, and taking a lead from the chemical literature, we have determined the existence of two different regimes for the growth rate of the gypsum crust according to the relative humidity.

Using this new model, simulations have been performed with real data acquired at Villa Ada in Rome and kindly provided by Arpalazio, the Rome regional authority for monitoring pollution. Useful indications were derived by our elaboration of these data. First, the growth of the crust is proportional to  $\sqrt{t}$  (where  $t$  is time). For instance, using Villa Ada data we have extrapolated from the experimental data of the first year (2006) to the following eight years. After one year, we obtain a crust

of  $4\mu\text{m}$ , with  $8.2\mu\text{m}$  after four years and  $12.5\mu\text{m}$  after nine years. This result allows us to quantify the consequence of crust removal after a given time (see Figure 3). Next, we established the influence of the variation of  $\text{SO}_2$  by a factor  $c$ . The external concentration of  $\text{SO}_2$ ,  $s(t)$ , was replaced by the value  $c \cdot s(t)$ , where  $c$  is a given constant. We again used 'Villa Ada' data, and simulated the front behaviour according to the different values of  $c$ . The results obtained show that the thickness of the front varies as  $\sqrt{c}$ . So, even if we were able to diminish the concentration of  $\text{SO}_2$  pollutant by four times, we would only obtain a reduction of one-half of marble waste.

We are now starting a collaboration with the General Direction of Cultural Heritage in Latium and with the 'Istituto Centrale per il Restauro' in order to undertake more significant tests of our approach.

#### Links:

<http://www.iac.rm.cnr.it/~natalini>  
<http://www.iac.rm.cnr.it/~natalini/ps/CFNsulf.pdf>  
<http://web.math.unifi.it/users/fasano/home.html>

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## Modelling Genetic Networks with Topological Constraints

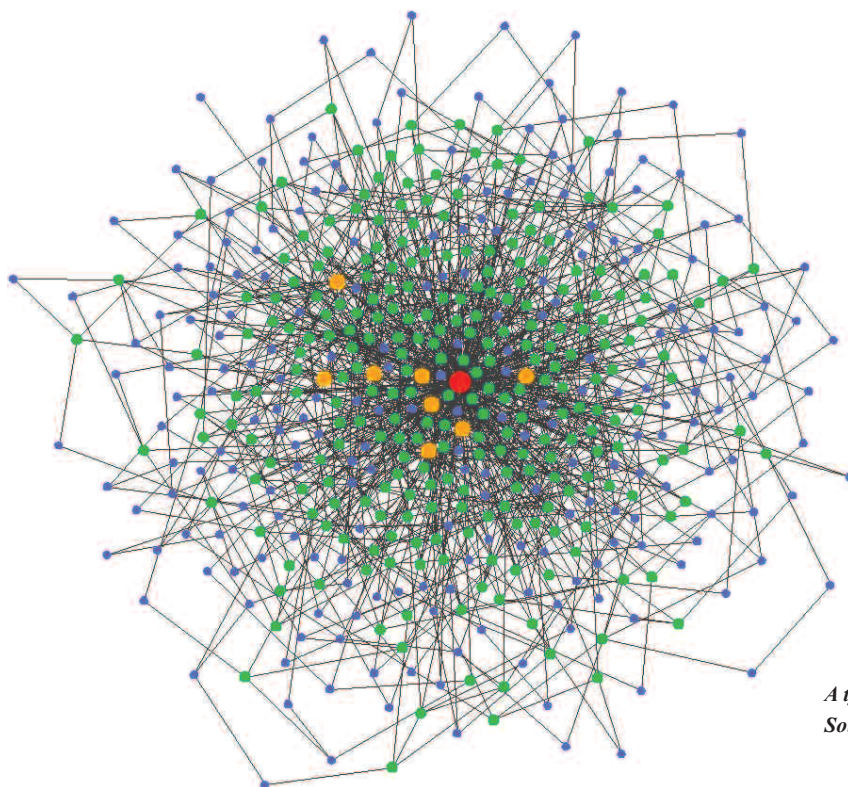
by Angela Grassi

*In the post-genomic era, identifying the structure of genetic networks is one of the main goals of Systems Biology. A project in which gene regulatory networks are modelled and reconstructed from time-course gene expression data is being undertaken by the Institute of Biomedical Engineering (ISIB-CNR) in collaboration with Lancaster University.*

The behaviour of a living cell is regulated by complex networks of interaction between DNA, RNA, proteins and small molecules. With the availability of complete genome sequences and large-scale microarray data, the last fifteen years have seen a growing interest in the study of intracellular networks.

Unravelling this complex organization is vital to obtaining a better understanding of normal and pathological cell physiology. In this work we focus on the so-called gene (or genetic) regulatory networks which describe the regulatory interactions at the gene level.

Genetic networks are usually visualized as directed graphs in which nodes represent genes and edges regulatory influences. In our model, edges are labeled with a sign (+ or -) indicating the nature of the regulation. The corresponding mathematical representation of gene interactions is the adjacency or gene



*A typical example of scale-free topology.  
Source: University of Chicago News Office.*

interaction matrix, in which the  $i,j$ -th element may be either +1, -1 or 0: respectively, these designators mean that gene  $i$  activates, represses or does not regulate the expression of gene  $j$ .

Among the several approaches which have been proposed to infer the structure of gene regulatory networks, we decided to adopt one based on graphical models. Starting from time-course gene expression data, we construct a Bayesian hierarchical model that takes into account the biological knowledge about transcription, the process by which messenger RNA (mRNA) is copied from the genetic instructions contained in a gene. This process is regulated by proteins called transcription factors. We model the dynamics of transcription via nonlinear differential equations in which the protein levels of regulators are considered as unobserved parameters. Another important parameter of the model is the adjacency matrix whose choice takes into account the available biological knowledge.

Most biological networks tend to be organized according to some characteristic features: a relatively short path length between any two nodes (small world property), the presence of many genes with few connections and few highly connected genes (hubs), and the lethal impact for the overall architecture

of the network of the deletion of a hub (centrality and lethality principle).

A particular class of networks that exhibits these features is the so-called scale-free class. The scale-free property means that the connectivity distribution (ie the probability distribution of the number of regulators of each gene) follows a power law.

Rather than inferring the topological structure from the data, we impose a scale-free topological constraint on the overall structure of the network choosing a power law for the connectivity distribution.

The identification of the model from real data is based on Markov Chain Monte Carlo (MCMC) techniques. The model is implemented via a hybrid Metropolis-Hastings and Gibbs sampler using the statistical software R. In the case of the adjacency matrix we use Approximate Bayesian computations, incorporating a frequentist testing strategy in the MCMC update.

The idea of imposing a Bayesian topological constraint on the overall structure of the network has already been used in a linear model framework. The novelty of our model resides in the use of a nonlinear model for transcription, which seems appropriate to better

exploit the biological knowledge about this process. Moreover in our dynamics of transcription we take into consideration that a gene could have several regulators which could be either repressors or activators.

The completion of the project includes the refinement of the R code for the MCMC implementation, and its application to a real dataset. Future activities will be devoted to the extension of our model, an investigation of different types of topological constraints and the introduction of biological knowledge about translation, the process by which mRNA is translated into proteins.

This work is the result of collaboration with Ernst Wit, head of the Medical Statistics Unit at the Department of Mathematics and Statistics, Lancaster University. Angela Grassi is supported by a grant of Regione Veneto (Azione Biotech II - DGR 2112/02-08-05) to ISIB.

#### **Links:**

<http://www.isib.cnr.it/~grassi/geneticnetworks/>  
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# A Model-Driven Data Provenance Method in a Semantic Web-Based Environment

by Tibor Gottdank

*The goal of data provenance is to provide a method and a standard with which to manage the validity and the origin of information. At SZTAKI, a model-level data provenance method is implemented in a distributed service-oriented system, as part of a Hungarian national research and development project called SINTAGMA (Semantic INtegration Technology Applied in Grid-based, Model-driven Architectures).*

The underlying principle of the SINTAGMA project (the project partners are IQSYS Computing Ltd., Budapest University of Technology and Economics (BME), HunorIS and SZTAKI) is to employ loosely coupled components and combine data-centric and process-based integration. This is done by providing appropriate wrappers via the integration of relational, object-oriented and semi-structured sources, as well as Web Services in a unified framework.

In SINTAGMA system, metadata (knowledge about information systems) are stored in a so-called model repository. This knowledge is represented by some formalism (description logics or UML). The properties of a model (concepts, structure of classes, description of relations of classes) are stored in a knowledge base. However, constraints have an important role in defining objects and relations. To determine these constraints, both OCL (Object Constraint Language) and the language of Description Logics are used.

The SINTAGMA system itself is both technically and semantically an integration tool for high-level access of heterogeneous data sources.

This model-level implementation is based on an internal language (SILan), which describes the models stored in the model repository (knowledge base). The metadata is stored as a model in the model repository in SINTAGMA. Each data source is described by a model, and the mappings between models present associations. The SINTAGMA system provides 'underway' (that is to say virtually) integrated data for the external components (eg for agents).

This article is focused on the data provenance issue in this distributed SOA environment. The goal is to provide the abil-

## Three steps within the typical use cases

**Step 1: Insertion of provenance data into models:** derivation of sources (eg MySQL database tables).

**Step 2: Derivation of data provenance information:** Adding attributes to given level classes takes place for provenance data (eg by Web Services).

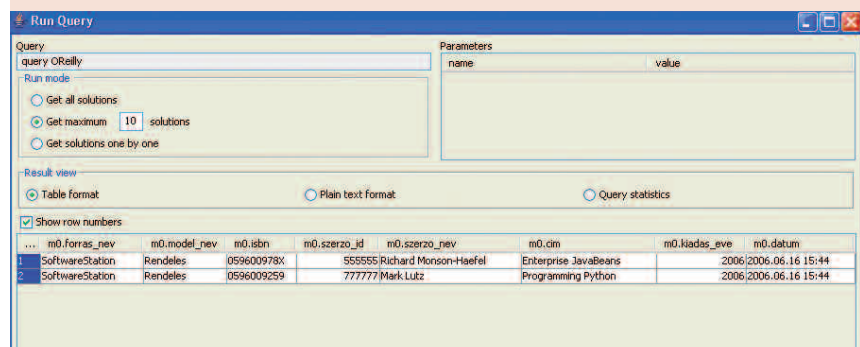
```
map bundle sws_order between SoftwareStation and
Order
abstraction sws_order
(m0:Amazon::Book->m1:Order::Book) {
  constraint
    m1.isbn=m0.isbn and
    m1.title=m0.title and
    ...
    m1.source_name="SoftwareStation"and
    m1.model_name="Order";
    m1.date="2007-03-14 10:55"
  };
};
```

Figure 1: Sample SILan code (bold indicates provenance information).

The derivation of source data consists of four use cases:

- Derivation of relations-level models. In the model repository the derivation is realized through abstraction. Within abstraction, values passed to particular provenance attributes are inserted into class attributes at the first point. The constant values, which correspond to given sources and higher-level model names, are added to attributes by the knowledge engineer.
- Derivation of more low-level models.
- Derivation of higher-level models. The derivation is processed among application-level models. In this case the derivation process has already occurred on the relations level.
- Association and derivation of higher-level models. This class derivation is on the application level as well, but the relation realized here is an association type relation.

**Step 3: Retrieval of provenance information:** Here the requested information can be queried.



Query		Parameters	
name	value	name	value
query O'Reilly			
Run mode			
<input type="radio"/> Get all solutions			
<input checked="" type="radio"/> Get maximum 10 solutions			
<input type="radio"/> Get solutions one by one			
Result view			
<input checked="" type="radio"/> Table format			
<input type="radio"/> Plain text format			
<input type="radio"/> Query statistics			
<input checked="" type="checkbox"/> Show row numbers			
m0.fornas_nev	m0.model_nev	m0.isbn	m0.szerzo_id
SoftwareStation	Rendeles	059600978X	55555 Richard Monson-Haefel
SoftwareStation	Rendeles	0596009259	77777 Mark Lutz
m0.cim	m0.kiadas_eve	m0.datum	
Enterprise JavaBeans		2006/2006.06.16 15:44	
Programming Python		2006/2006.06.16 15:44	

Figure 2: Result of the above query in the GUI of SINTAGMA system.



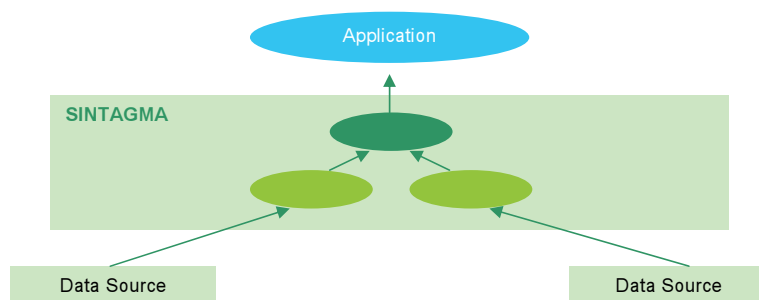


Figure 3: Data integration process via SINTAGMA system.

ity to access and analyse provenance, which records past events and provides users with a guide to steps in the future.

Technically, the models (in the model repository) are completed with provenance information. The provenance information is derived and queried like other information. The method is a detailed guide that the knowledge engineer can use to append new information and to maintain existing data. Additional information contains the source name, the current time and the model name. This information is never lost during the data derivation, meaning the end user is also able to use it.

The method consists of three steps within the typical use cases that cover the whole provenance activity. The use cases are

based on a general situation where the user is looking for a piece of information and wants to be sure of the authenticity of incoming data. First, the sources are derived. In the second step the data provenance information itself is derived. Through derivation, the provenance information moves to a higher level and provenance attributes are inserted into other attributes of class objects. Provenance data queries and the identification of sources are therefore possible at all levels of data derivation (third step).

The SINTAGMA technology (and the model-driven provenance method within it) provides cost-effective integration of information for medium-size enterprises, where the development of quality and efficiency of services is important.

Currently, the potential target field includes map businesses, travel agencies, libraries and museums. In academia, BME and SZTAKI will use the results of basic and applied research in their education and research program. By merging, filtering, grouping data of different data providers, in cooperation with the Hungarian News Agency (MTI) and National Széchenyi Library (OSZK), SZTAKI provides the Hungarian Digital Library with the possibility of effective data search.

The project (completed this summer) will demonstrate the wide applicability of the technology to be developed using two significantly different application environments. First, the IT services linked to the Hungarian cultural heritage (building on the National Digital Repository) will be improved, and second, specific problems suffered by SMEs in data integration and electronic business/commerce (related to the so-called Enterprise Information Integration market trend) will be solved.

**Link:**

<http://www.sintagma.hu>

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## A Federated Architecture-Based E-Business Platform

by Balázs Pataki and László Kovács

*While SMEs (small, medium and micro enterprises) are the largest group of businesses in Europe, their requirements for doing business with each other in an interoperable and cost-effective way have not been in focus until the last couple of years. The European Commission has sponsored the IST project ABILITIES (Application Bus for Interoperability In Enlarged Europe SMEs) to build a comprehensive solution for SMEs in an enlarged Europe. This will be achieved by studying, designing and implementing a B2B enterprise interoperability solution; such a solution would involve a federated architecture based on adaptive and intelligent UBL active messages to support complete Order-to-Invoice processes of SMEs.*

The aim of the ABILITIES project is to implement the ABILITIES Interoperability Bus (AIB) based on an Enterprise Service Bus (ESB) solution. This will help SMEs of new European member states and candidate countries in specific industries to do business with each other in a more straightforward way. Five such industries and numerous SMEs

active in those industries have been selected as testbeds for ABILITIES by the head of an umbrella organization (eg incubators and industry associations) in each country. The industries and countries involved are the retail industry in Lithuania, the high-tech industry in Slovakia, the agro-food industry in Turkey, the wood industry in Romania and the

tourism industry in Hungary. The research partners involved in the project are TXT e-Solutions, Department of Distributed Systems of SZTAKI, FhG-IPA, Frankfurt am Main University, Kaunas University of Technology, Kosice Technical University and the Middle East Technical University Ankara.

### Problems Related to Business Processes

IT solutions address different needs and present different opportunities to SMEs than to large enterprises. This is particularly the case for businesses in new and emerging member states, which in many cases do not even have a (suitable) IT infrastructure, and whose business communication and process execution are based on phone, fax and mail. A survey conducted by ABILITIES has shown, for example, that in Lithuania a typical SME with its current business infrastructure initiates 1000 phone calls per month, 100 of which result in some misunderstanding between partners. Among other things, this survey also revealed that in an average SME, two errors occur when filling in a form, the probability that a business document will be lost is 20%, and the probability that a given document can be found within two minutes is 25%.

### The Federated Solution

The solution proposed by ABILITIES deals with these process- and communications-related problems by implementing a customized Enterprise Service Bus (ESB) based on Universal Business Language (UBL). This can be deployed and provided by a third-party service provider – for example, by the umbrella organization of a specific industry – and is based on a federated architecture that seems more suitable for SMEs than traditional unified and integrated business solutions.

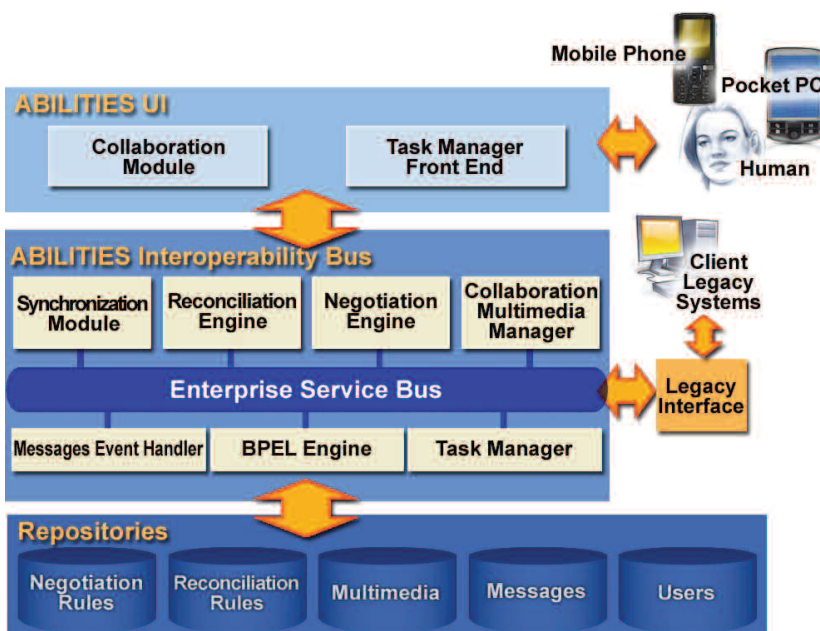
Traditional integrated models require each business partner to use the same data formats and protocols; in contrast, unified models define a common metamodel and all partners convert their own data formats and protocols to the metamodel in order to achieve mutual understanding. The federated interoperability approach, on the other hand, does not require business partners to completely conform to a specific or metamodel. When ambiguities or discrepancies emerge – for example, due to different interpretations of a business document – the possibility exists to resolve the conflict with some other means that may be out of the scope of the current business process.

Conflict resolution can be either automatic or may require human intervention. To provide interoperability at the level of document formats, ABILITIES provides an ontology-based automatic approach driven by a set of reconciliation rules. This approach allows specialized versions of common business documents to be created, which while being customized for a specific market or even a specific company in that market, can still be exchanged among business partners by having a commonly agreed ontology of business terms. Reaching a common understanding at the level of document content however, requires a different approach that is not strictly metamodel-based and uses various forms of on-the-fly mediation involving programmed or human intel-

ligence. For this, ABILITIES selected the federated model approach and the use of groupware and multimedia extensions, combined with existing interoperability solutions. The system initially tries to deal with the business flow between two partners using a pre-programmed logic (a workflow in a business process engine). When a condition or situation is met that cannot be automatically resolved (no handler is available for the exceptional case in the workflow), or if common understanding between the two partners cannot be reached (ie a misunderstanding or misinterpretation of business document content occurs), ABILITIES provides alternative ways for the conflict to be handled. These take the form of support for collaborative tools (negotiation, notification, groupware tool support) and multimedia enhancement of business documents (non-textual information to support the common understanding of document content).

### Evaluation of ABILITIES

The ABILITIES system is expected to be deployed in testbeds in the fall of 2007. In its final form it will provide three interfaces for SMEs: a Web portal, a GUI optimized for mobile phones, and a legacy system interface based on Web services. The testbeds will evaluate the AIB under actual business conditions and will provide performance indicators to measure its effect on the way SMEs function.



Architecture of the Abilities Interoperability Bus and the accompanying services.

### Links:

ABILITIES project:  
<http://services.txt.it/abilities/>  
Department of Distributed Systems of  
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# KING PONG: Towards the Inclusion of Impaired Users in Computer Games

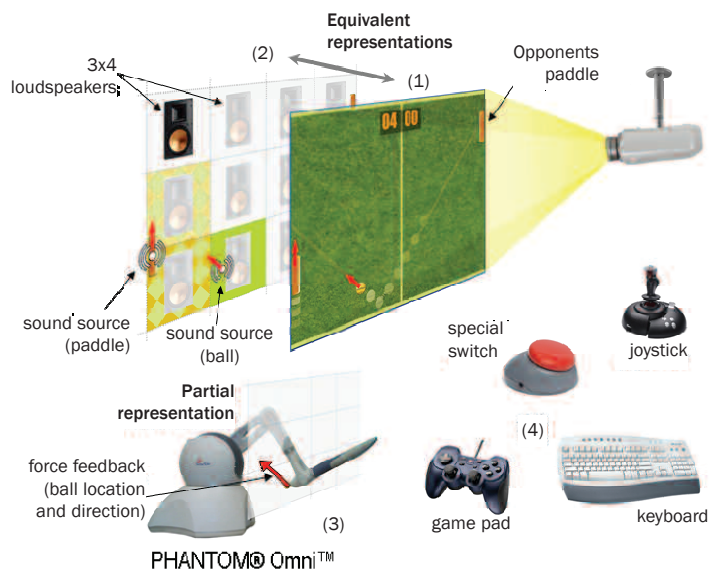
by Apostolos Stamou, Anthony Savidis and Constantine Stephanidis

*KING PONG, a fully accessible remake of the classic Pong game, has been developed to foster the inclusion of people with disabilities to computer game entertainment. It constitutes a research prototype of innovative display and interaction techniques that are suitable for visually and physically impaired people as well as able-bodied users, thus promoting interaction and gaming between diverse user groups.*

The vast majority of existing computer games require advanced motor and sensory skills, such as simultaneous key-strokes or the concurrent use of two input devices (for instance, keyboard and mouse). In addition, the game industry is investing in 3D games in which content is conveyed entirely through 3D inaccessible artwork. The audio component of these games is usually auxiliary to the experience, its function being to improve the overall atmosphere of the game. As a result, these games are often rendered inaccessible to people with disabilities, especially those who are visually or motor impaired.

To this end, ICS-FORTH, in the context of the European IST Specific Target Research Project MICOLE (IST-2003-511592), has designed and developed KING PONG. This is a remake of the classic Pong game that was originally developed by Atari Inc., and which has been redesigned to accommodate the needs both of able-bodied and disabled players. A number of innovative display and interaction techniques have been proposed and validated by means of this research prototype, in order to encourage uptake of the proposed concepts by the game industry.

KING PONG was designed under a Universal Access and Design for All perspective, and has been evaluated both with HCI (human-computer interaction) experts and representative users. In particular, the primary goals of this work are: (a) to define appropriate design principles, building on the research in cross-modal equivalence and multi-sensory perception, which can significantly reduce the effect of certain user limitations on interaction and gaming; and (b) to increase awareness of game accessibility among developers and to extract particular guidelines for the development and assessment of accessible games while outlining potential pitfalls.



**Overview of the KING PONG gaming environment: (1) graphical display; (2) auditory display; (3) haptic display; (4) potential input devices.**

The KING PONG prototype offers several novel features that will help to meet these objectives. These are summarized below.

**Alternative displays.** KING PONG supports alternative ways of conveying game information to diverse user groups, including a visual display, a fully equivalent auditory display, and a partial haptic display. The visual display provides graphical information by means of standard display devices (eg a monitor or projector). The auditory display constitutes an auditory media space produced by a number of loudspeakers that support spatialized audio. In this way, the game space is represented by a grid of auditory cells, and each game entity by a distinct sound source that lies within a certain cell while moving across the grid, thus allowing visually impaired players to locate them at any time. The haptic display uses the PHANTOM® Omni™ haptic device that presents contextual (ie partial) game information, such as the position of the ball on the game ter-

rain and its direction. In this case, bimanual (two-handed) interaction is supported, in which the haptic device is held by the non-dominant hand and serves as a main or auxiliary display channel, and the dominant hand is preserved for game interaction (eg controlling the paddle through an input device).

**Alternative input devices.** KING PONG supports a variety of input devices and assistive technology, including keyboard, special switches, joystick and game pads, thus making interaction and gaming possible regardless of the types of disability users may have.

**Various player modes.** KING PONG supports both a single-player mode, in which the player competes against the computer, and a two-player mode, either via sharing the same computer or over a network (Internet). In particular, the two-player mode allows gaming among people with different types of (dis)ability (eg between a blind or motor-impaired person and an able-



bodied user). In addition, KING PONG supports several add-ons for addressing the needs of novice users. For instance, vibration controllers are supported in order to convey cues about the direction in which the paddle should be moved for reaching the oncoming ball.

Intelligent opponent and difficulty levels: KING PONG provides various levels of difficulty (and simulates the com-

puter opponent in a nontrivial way), in order to ensure that gaming will be challenging and interesting for all kinds of players, with or without disabilities. We hope thereby to promote gaming and socialization between diverse user groups.

Accessible user interface: Finally, during the design of KING PONG, particular attention has been paid to accommo-

dating good design practices in the development of an accessible and usable interface. Moreover, synthetic speech output has been integrated to allow non-visual navigation of the game menus.

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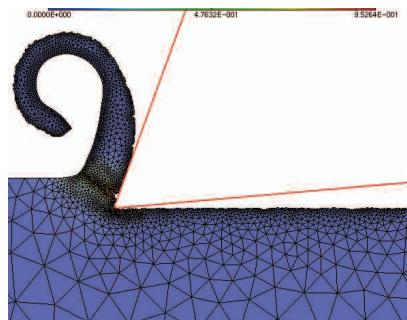
## Perfect Forming with Adaptive Meshing

by Paul-Louis George and Houman Borouchaki

*The Japanese steel manufacturer Nippon Steel Corporation has selected BL2D, a bidimensional mesh generator software package, to better simulate and optimize thin sheet cut-outs and forming. BL2D was jointly developed by INRIA and UTT, the Troyes University of Technology.*

BL2D is a robust, rapid, reliable and adaptive bidimensional mesh generator. Nippon Steel called on BL2D's talents to improve the simulation of thin sheet forming - destined above all for automotive markets - using methods such as stamping and orthogonal cutting, or machining techniques such as planning. Such simulations have been used for many years in industry for all part-forming operations, and employ finite element methods. This 'virtual forming' is used to measure the rapidity and quality of forming methods. This makes it possible to optimize the machines' real operating parameters, such as stamping or planning speed, or the impact of wear and tear on cutting matrices. All of these factors can have a major impact on the cost of industrial processes that involve the manufacture of millions of parts. Until now however, simulations were hindered by the quality of meshes that were implemented manually.

In the current version of BL2D-V2 (coupled with the computing software 'Abaqus'), the meshing is automatically adapted and is deformed by refining the meshes (equilateral triangles that are as regular as possible) at key stages of the simulation. Of interest to steel manufacturers is the ability to simulate sheet forming using a highly accurate mesh. Thanks to its automatic remeshing, this can adapt to areas in which the majority of constraints and deformations are found; for example, where the part is in contact with the tool or where it is most damaged. With BL2D, this operation



*Simulation of orthogonal cutting using standard Abaqus behaviour law.*

© Projet GAMMA / UTT

has become almost transparent. Some 3000 remeshes are needed to simulate orthogonal cutting (a matrix cold-cuts the sheet by moving from top to bottom). In total, this requires only one hour from the two weeks required to complete the mechanical simulation computation. The result is improved quality and rapidity for the simulation.

Apart from this example, the strength of our automatic meshing solution lies in its generic nature. This unique approach has enabled the development team to address a large number of industrial problems in both solid mechanics (such as this particular case) and fluid mechanics. This explains why BL2D has been adopted by Alcatel and Snecma, and why BLSurf, a piece of surface-meshing software based on parametric patches that is well suited to

solid and fluid mechanics, is used by Dassault Aviation, or more unexpectedly, by Lectra for a virtual clothing application.

These licence loans provide the means by which new challenges can be tackled. For example, the collaboration with Nippon Steel should extend into the hitherto unexplored field of 3D simulation. Ten researchers are currently involved in one way or another, as well as three jointly supervised doctoral students. The agreement with Nippon Steel provides yet more proof of the quality of solutions developed as part of this collaboration, which is enhancing skills in mesh generation in INRIA's Gamma (Automatic Mesh Generation and Adaptation Methods) research team and in mechanical and thermal simulations at Lasmis..

**Links:**

<http://www-rocq1.inria.fr/gamma/eng.php>  
<http://www-lasmis.utt.fr/>

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## CAiSE'07 - the 19th Conference on Advance Information Systems Engineering

by John Krogstie

CAiSE'2007 was the 19th in the series of International Conferences on Advanced Information Systems Engineering. This year's conference was located in Trondheim and hosted by the Norwegian University of Science and Technology. The conference thereby returned to the city where the third CAiSE conference was held, in 1991. The conference and accompanying workshops took place 11-15 June 2007, and gathered more than 300 participants from 29 countries.

Since the first CAiSE was organised in Stockholm in 1989, the conference has grown to become one of the most prestigious international conferences in the intersection between information systems, software engineering, database technology and several related fields. The proceedings of CAiSE 2007 have been published by Springer in the Lecture Notes in Computer Science (LNCS) series as volume 4495.

The special theme of CAiSE'07 was 'Ubiquitous Information Systems Engineering', reflecting that modern information systems often span activities performed in several organisations and at different geographical locations. They often support the untethered mobility of their users. The systems have already today a large impact on every day life in the organisations and on the individuals. As we move towards ambient, pervasive and ubiquitous computing this impact will increase significantly.

The response to the call for papers was overwhelming. 301 papers were submitted, which is a new record for CAiSE. The program committee selected 40 top-quality papers, the acceptance rate for CAiSE'07 was thus of around 13%. Several other high quality papers were selected for the CAiSE Forum, initiated at CAiSE'2003 in Velden in order to stimulate open discussions of high-quality on-going research.

The success of CAiSE'07 is also evident by the many top-quality workshops that were arranged as CAiSE pre-conference events. The longest running, the REFSQ series on Requirements Engineering: Foundation for Software Quality was organised for the 13th time in Trondheim. Over the years it has evolved into a working conference, this year with its own LNCS proceedings published by Springer. The 'EMMSAD'07 Workshop on Exploring Modelling Methods for Information Systems Analysis and Design' was organised for the 12th time. The 'AOIS-2007 Workshop on Agent-Oriented Information Systems' was organised for the 17th time, and with CAiSE for the 8th time. Other high quality international workshops this year were BPMDS'07 on Business Process Modelling, Development, and Support, BUSITAL'07 on Business IT alignment and WISM'07 on Web information systems modelling.



*Arne Sølberg in the panel session "The Future of Information Systems Engineering - ISE research from 1977, in 2007, and how it will be in 2037".*

The special theme of CAiSE'07 was high-lighted by an additional workshop on 'Ubiquitous Mobile Information and Collaboration Systems, UMICS'07', and by three industrial keynote presentations: Ora Lassila of Nokia, USA on "Setting Your Data Free: Thoughts on Information Interoperability", Pekka Abrahamsson of VTT, Finland, on "Agile Software Development of Mobile Information Systems", and Christen Krogh of Opera Software, Norway with a talk entitled "40 million users, 300 engineers, 40 enterprise customers, 7 development locations, and 1 cvs - lessons learned through design, development and deployment of the Opera browser".

Contact with industry was emphasised through a one-day industrial seminar on Agile Methods in Practice, organised by Torgeir Dingsøy. As usual, a doctoral consortium was also organised in conjunction with CAiSE, giving research students an opportunity to present and discuss their Ph.D. topics and plans face to face with internationally leading researchers in their fields.

CAiSE'07 was also an occasion to honour one of the founding fathers of the CAiSE series and organizing chair of the 1991 conference, Professor Arne Sølberg, vice-president of ERCIM, who celebrated his 67th birthday in 2007. 67 is the usual retirement age in Norway, although Arne has promised to be working until 70 (at least!). A symposium to Professor Sølberg's honour was arranged before CAiSE'07 as an additional pre-conference event, were the chapters of a book published on Springer put together in secret to his honour, Conceptual Modelling in Information Systems Engineering, was presented.

CAiSE'2007 was sponsored by ERCIM.

### Link:

<http://caise07.idi.ntnu.no/>

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# HCI International 2007

by Constantine Stephanidis

HCI International 2007, the 12th International Conference on Human-Computer Interaction was held in Beijing on 22-27 July, jointly with the Symposium on Human Interface (Japan) 2007, the 7th International Conference on Engineering Psychology and Cognitive Ergonomics, the 4th International Conference on Universal Access in Human-Computer Interaction, the 2nd International Conference on Virtual Reality, the 2nd International Conference on Usability and Internationalization, the 2nd International Conference on Online Communities and Social Computing, the 3rd International Conference on Augmented Cognition, and the 1st International Conference on Digital Human Modeling.

HCI International is the worldwide renowned international forum for the dissemination and exchange of up-to-date scientific information on theoretical, generic and applied areas of Human-Computer Interaction.

This event was one of the biggest ever organised in the fields related to Human-Computer Interaction and Information Society Technologies, and attracted an unprecedented number of 2300 participants from 76 countries, representing the research and academic communities as well as industry.

The conference programme was organised into 10 thematic areas, namely Ergonomics and Health Aspects of Work with Computers, Human Interface and the Management of Infor-

This year, HCI International and the affiliated conferences explored a wide variety of new hot topics which reflect and contribute to a paradigm shift towards ubiquitous interaction, intelligent environments and interactive technologies supporting virtually any aspect of human life and activities in a global and social perspective.

The Proceedings have been published by Springer in the LNCS/LNAI series, and consist of 17 volumes containing 1681 papers in total. The Proceedings are also available on-line through the LNCS Digital Library (<http://www.springer.com/lncs>), readily accessible by all subscribing libraries around the world.

HCI International 2009 and the affiliated Conferences will be held in San Diego, California, USA, 19-24 July 2009 (<http://www.hcii2009.org>).

## Link:

<http://www.hcii2007.org>

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# Cross-Language Evaluation Forum - CLEF 2007

by Carol Peters

*The results of the eighth campaign of the Cross-Language Evaluation Forum were presented at a two-and-a-half day workshop held in Budapest, 19-21 September, immediately following the eleventh European Conference on Digital Libraries (ECDL 2007). The workshop was attended by 120 researchers and system developers from academia and industry.*

The main objectives of the Cross-Language Evaluation Forum (CLEF) are to stimulate the development of mono- and multilingual information retrieval systems for European languages and to contribute to the building of a research community in the multidisciplinary area of multilingual information access (MLIA). These objectives are realised through the organisation of annual evaluation campaigns and workshops. The scope of CLEF has gradually expanded over the years. While in the early years, the main interest was in textual document retrieval, the focus is now diversified to include different kinds of text retrieval across languages and on different kinds of media.

## Evaluation Tracks

In CLEF 2007 seven tracks were offered to evaluate the performance of systems for:

- mono-, bi- and multilingual document retrieval on news collections (Ad-hoc)
- mono- and cross-language structured scientific data (Domain-Specific)



*The Opening Plenary Session of HCI International 2007.*

mation, Human-Computer Interaction, Engineering Psychology and Cognitive Ergonomics, Universal Access in Human-Computer Interaction, Virtual Reality, Usability and Internationalization, Online Communities and Social Computing, Augmented Cognition, and Digital Human Modeling.

The programme featured one plenary session, 256 parallel paper sessions, 18 tutorials, two workshops, and 371 poster presentations. The keynote speaker was Professor Takeo Kanade, from Carnegie Mellon University Pittsburgh, PA., USA, and National Institute of Advanced Industrial Science and Technology, Tokyo, Japan. His enlightening talk was entitled "Digital Human Modeling and Quality of Life Technology".



- multiple language question answering (QA@CLEF)
- cross-language retrieval on image collections (ImageCLEF)
- cross-language speech retrieval (CL-SR)
- multilingual web retrieval (WebCLEF)
- cross-language geographic retrieval (GeoCLEF).

### Test Suites

Most of the tracks adopt a corpus-based automatic scoring method for the assessment of system performance. The test collections consist of sets of statements representing information needs known as topics (queries) and collections of documents (corpora). System performance is evaluated by judging the documents retrieved in response to a topic with respect to their relevance (relevance assessments) and computing recall and precision measures.

The following document collections were used in CLEF 2007:

- CLEF multilingual comparable corpus of more than three million news documents in 13 European languages
- CLEF domain-specific corpora: English/German and Russian social science databases
- Malach collection of spontaneous speech in English and Czech, derived from the Shoah archives
- EuroGOV, ca 3.5 M webpages crawled from European governmental sites.

The ImageCLEF track used collections for both general photographic and medical image retrieval:

- IAPR TC-12 photo database; PASCAL VOC 2006 training data
- ImageCLEFmed radiological database consisting of six distinct datasets; IRMA collection for automatic image annotation.

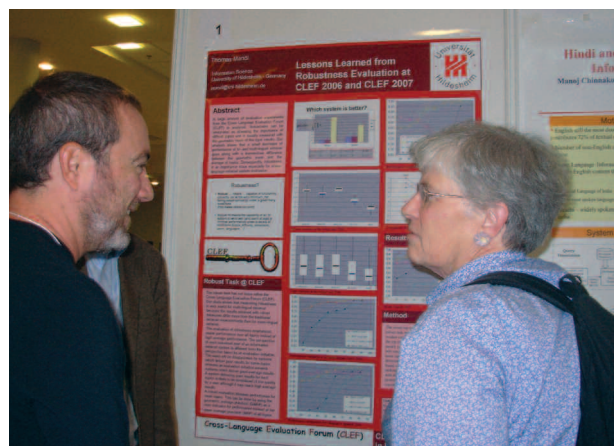
Diverse sets of topics or queries were prepared in many languages according to the needs of the various tracks. For example, this year the Ad Hoc track offered mono- and bilingual tasks for central European languages (Bulgarian, Czech and Hungarian) plus a bilingual task encouraging system testing with non-European languages against English documents. Topics were made available in Amharic, Chinese, Oromo and Indonesian. A special sub-task regarded Indian languages with Hindi, Bengali, Tamil, Telugu and Marathi proposed for search tasks against an English target collection.

### Participation

Participation again showed a good mix of newcomers and veteran groups with long experience at CLEF. 81 groups submitted results for one or more of the different tracks: 51 from Europe, 14 from North America, 14 from Asia, and just 1 each from South America and Australia.

### Workshop

The annual workshop plays an important role by providing the opportunity for all the groups that have participated in the evaluation campaign to get together comparing approaches and exchanging ideas. The schedule was divided between plenary track overviews, plus parallel, poster and breakout sessions presenting this year's experiments and discussing ideas for the future. There were several invited talks. Noriko Kando, National Institute of Informatics Tokyo, reported the lessons learned at NTCIR-6 and plans for NTCIR-7 (NTCIR is an evaluation initiative focussed on testing IR systems for Asian languages), while Mandar



Poster session at CLEF 2007.

Mitra, Indian Statistical Institute Kolkata, presented FIRE, a new Forum for Information Retrieval Evaluation for Indian languages. Eduoard Geoffrois of the French government described the objectives of the much publicised and ambitious Quaero programme, which has the goal of developing multimedia and multilingual indexing and management tools for professional and general public applications.

The presentations given at the workshop and detailed reports on the experiments of CLEF 2007 and previous years can be found on the CLEF website. The preliminary agenda for CLEF 2008 will be available from mid-November.

### From CLEF to Treble-CLEF

Over the years, CLEF has done much to promote the development of multilingual IR systems. However, the focus has been on building and testing research prototypes rather than developing fully operational systems. We believe that the time is now mature to begin to transfer the knowledge acquired to an application setting and for this reason we are about to launch a new activity, "Treble-CLEF" with three main goals:

- To promote high standards of evaluation in MLIA systems using three approaches: test collections; user evaluation; and log file analysis
- To sustain an evaluation community by providing high quality access to past evaluation results
- To disseminate knowhow, tools, resources and best practice guidelines, enabling information system developers to make content and knowledge accessible, usable and exploitable over time, over media and over language boundaries.

The aim will be to provide applications that need multilingual search solutions with the possibility to identify the technology which is most appropriate and to assist technology providers to develop competitive multilingual search solutions.

### Links:

CLEF: <http://www.clef-campaign.org>

FIRE: <http://www.isical.ac.in/~clia/>

NTCIR: <http://research.nii.ac.jp/ntcir/>

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## Call for Participations

# AIM@SHAPE Final Workshop

Genova, Italy, 4 December 2007

The AIM@SHAPE Network of Excellence has fostered the development of new methodologies for modelling and processing the knowledge related to digital shapes. This knowledge is concerned with the geometry (the spatial extent of the object), the structure (object features and part-whole decomposition), attributes (colours, textures), semantics (meaning, purpose), and has interaction with time (morphing, animation).

The final AIM@SHAPE workshop will present and discuss the main objectives achieved by the AIM@SHAPE NoE during the period 2004-2007, with special emphasis on the the definition of a common framework for formalising, processing and sharing shape knowledge through the set up and development of an e-Science framework.

Four ERCIM member organisations have participated in the network: Institute of Applied Mathematics and Information Technology (IMATI)-CNR, Italy; Fraunhofer Institute for Computer Graphics (IGD), Germany; École Polytechnique Fédérale de Lausanne (EPFL), Switzerland; and INRIA, France.

### More information:

<http://www.aimatshape.net/>

## CALL FOR PARTICIPATION

# Sixth International Conference on Networked Learning 2008

Halkidiki, Greece 5-6 May 2008

NLC is a research-based conference on networked learning in higher education and lifelong learning. The conference is an opportunity to participate in a forum for the critical examination and analysis of research in networked learning, ie learning and teaching carried out largely via the internet/web which emphasises collaborative and cooperative learning, through dialogue and group work together with interaction with online materials, and collaborative knowledge production. Topics covered include:

- Social Networking in Networked Learning
- Designing Learning Spaces
- Ubiquitous Learning
- Embedding Networked Learning in Institutions: Policy & Practice
- Networked Lifelong Learning
- Interculturality
- Personalisation
- Learner's & Teacher's Experiences
- Methodologies for Researching Networked Learning
- Learning Theories and Processes

Keynote speakers include:

- Yannis Dimitriadis, Associate Professor, Director of the GSIC/EMIC group, School of Telecommunications Engineering, University of Valladolid, Spain
- Diana Laurillard, London Knowledge Lab, Institute of Education
- Charalambos Vrasidas, Associate Professor of Learning Technologies at the School of Education at Intercollege

The conference will be hosted this year by the Technological Educational Institute of Thessaloniki and the University of Piraeus at the Sani Beach Hotel, Halkidiki, Greece.

### More information:

<http://www.networkedlearningconference.org.uk/>

# Vacancies for PhD Research Positions in Computer Science at UCL, Belgium

The Université catholique de Louvain (UCL) invites applications for several open PhD research positions in the Department of Computing Science & Engineering (INGI), in the context of different research projects.

A detailed list of all open positions, including research themes, sought profiles and expected durations, is available at <http://www.uclouvain.be/3996.html>. Most of the vacant positions can be filled in immediately. There is no closing date; candidates will be considered on a first-come first-served basis, provided that they meet all profile and administrative requirements.

Qualifying candidates will demonstrate excellent academic grades, a strong interest for research, good team-working abilities and a working practice in English. Knowledge of the French language is not a prerequisite, but selected candidates are expected to acquire a working practice in French once employed.

UCL is the oldest Belgian university and is consistently ranked in the top 100 universities worldwide. It is located in the new city of Louvain-la-Neuve, 25 km south-east of Brussels, the capital of Belgium, in the heart of Europe.

For more information on these applications, please contact Kim Mens ([Kim.Mens@uclouvain.be](mailto:Kim.Mens@uclouvain.be)) or the contact person mentioned for each position.

### More information:

<http://www.uclouvain.be/3996.html>

### Research performed at the department:

<http://www.info.ucl.ac.be/>.

### Official university salary scales:

[http://www.sper.ucl.ac.be/ucl/Informations\\_chiffres/Baremes/sommairebareme.htm](http://www.sper.ucl.ac.be/ucl/Informations_chiffres/Baremes/sommairebareme.htm)

## CALL FOR PARTICIPATION

## TRIDENTCOM 2008 - 4th International Conference on Testbeds and Research Infrastructures for the Develop- ment of Networks & Communities

Innsbruck, Austria, 18-20 March 2008

Telecommunication infrastructures play a vital role in modern society. Advances in the range of network service offerings, performance, quality of service, security, and ubiquity continue to flourish, despite global economy fluctuations. Access to experimental infrastructures for real-life applications by specific user communities benefits all of the stakeholders involved: the end users, because of the first-hand evaluation of the provided services, the researchers and infrastructure experimenters, because of the knowledge gained from hands-on study and analysis, and the service providers, because of the business exploitation of the network.

The goal of TridentCom is to create a forum where telecommunication networks researchers, vendors, providers and users can exchange ideas on past experience, requirements, needs, and visions for future establishment of such infrastructures. It showcases experimental activities, such as testing, verification, integration, measurement, and deployment, which are pivotal to achieving next generation communications.

**More information:**

<http://www.tridentcom.org/>

## CALL FOR PAPERS

## Shape Modeling International 2008

Stony Brook, New York, USA, 4-6 June 2008

Shape Modeling International provides a premium international forum for the dissemination of new mathematical theories and novel computational techniques for modeling, simulating, and processing digital representations of shapes and their properties to a community of researchers, developers, practitioners, and students in academia and industry across a wide range of fields.

SMI'08 will immediately follow the ACM Solid and Physical Modeling Symposium 2008 (SPM'08), to be held on June 2-4, 2008, in Stony Brook University, Stony Brook, New York, USA. Both SPM'08 and SMI'08 events will be co-located in Stony Brook, and are parts of the 2008 Stony

Brook Modeling Week that features International Joint Convention on Shapes and Solids (ICSS'08).

**Important Dates**

- 27 November 2007: Abstracts due
- 4 December 2007: Full papers due
- 31 January 2008: Acceptance decisions
- 1 March 2008: Camera-ready papers due

This year, SMI'08 is soliciting contributions in terms of state-of-the-art reports.

**SHREC Contest**

The third edition of the SHREC - 3D Shape Retrieval Contest will be organized in conjunction with SMI'08. The general objective of the contest is to evaluate the effectiveness of 3D-shape retrieval algorithms.

**More information**

<http://www.cs.sunysb.edu/smi08/>

## CALL FOR PARTICIPATION

## RISE 2007, 4th International Workshop on Rapid Integration of Software Engineering Techniques

Luxembourg 26-27 November 2007

RISE 2007 is an international forum for researchers and practitioners interested in the advancement and rapid application of novel, integrated, or practical software engineering approaches, being part of a methodological framework, that apply to the development of either new or evolving applications and systems. It provides a nice opportunity to present and discuss the latest research results and ideas in the rapid and effective integration of software engineering techniques.

**Main Topics**

The following constitute the core list of the key software engineering domains that form the focal point of the RISE workshop: software and system architectures, software reuse, software testing, software model checking, model driven design and testing techniques, model transformation, requirements engineering, lightweight or practice-oriented formal methods, software processes and software metrics, automated software engineering, software patterns, design by contract, defensive programming, software entropy and software re-factoring, extreme programming, agile software development, programming languages, software dependability and trustworthiness

The workshop is organised by the ERCIM Working Group "Rapid Integration of Software Engineering Techniques" .

**More information:**

<http://rise2007.uni.lu>



### VTT and Nokia Developed a Simulation Model for more Effective Product Development

Nokia and VTT have developed a system dynamic model asset to solve complex process challenges. The model asset is utilized in improving product process performance and productivity. A couple of spin-off applications have been developed for specific purposes, eg, system research and process improvement as well as coaching and competence development. The Finnish Society of Automation presented their automation prize to the developers Lasse Pesonen and Simo Salminen from Nokia and Jean-Peter Ylén and Pasi Riihimäki from VTT as a recognition for remarkable R&D work on 4th September, 2007.



*Left to right: Simo Salminen (Nokia), Pasi Riihimäki (VTT), Jean-Peter Ylén (VTT) and Lasse Pesonen (Nokia).*

The processes in R&D depend more on people than machines thus making mathematical simulation demanding. The software developed by VTT and Nokia can be used for example for optimizing and managing processes as well as coaching. Modelling based on system dynamics has been utilized in this tool aimed at analysing and concretizing reason-consequence relationships. With this automation, system and weather theory can be applied in practice to production, economic and social systems.

### Spanish Awards in Informatics

During the Second Spanish Conference on Informatics (CEDI 2007) in Zaragoza on 11-14 September 2007, two national awards have been granted to prominent Spanish researchers. The José García Santesmases Award to the most outstanding professional career has gone ex-aequo to Prof. Enric Trillas from the Universidad Politécnica de Madrid (UPM) and Prof. Ramón Puigjaner from the Universidad de las Islas Baleares (UIB). Enric Trillas was the pioneer of Soft Computing in Spain. Ramón Puigjaner has played a very prominent role in the development of the Spanish curriculum in informatics. The Aritmel Award for the researcher developing the most significant scientific contributions to informatics engineering was given to Prof. José Duato, from the Universidad Politécnica de Valencia (UPV). José Duato has strongly contributed to the development of high performance computer architectures.

Also, two national awards recognized the activity of private and public institutions in the area. The company Panda Security received the Mare Nostrum Award and the Spanish ministry for education and science (Ministerio de Educación y Ciencia) got the Ramón Llull Award.

### Apple ARTS award for INRIA's Cardiosense3D Action

The Apple Research & Technology Support (ARTS) programme diploma was awarded in recognition of INRIA's Cardiosense3D national action. The project develops software tools used in modelling the electromechanical activity of the heart. The teams involved are developing a customised heart simulator which will provide specialists with a 3D view of each patient's physiological parameters (contraction mechanism, electrophysiology, perfusion, metabolism).

Apple is no newcomer to corporate sponsorship. Its ARTS programme was set up to support leading European research institutes and help young scientists through their projects by giving them access to Apple technology. ARTS award winners receive \$30,000 worth of Apple hardware, software and assistance.

Apple has shown a particularly keen interest in INRIA's activities and wished to commend the scientific excellence of the Institute's young researchers.

Miguel Fernandez, coordinator of Cardiosense3D, received the prize from Massimo Marino (European Manager of the ARTS programme/Apple Europe Education and Research Team) during a ceremony on 11 July, in the presence of Richard Ramos, Education and Research Manager of Apple France, and Antoine Petit, Director of the INRIA Paris - Rocquencourt research centre.

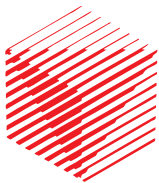
### Royal Honour for Paul Vitányi

Paul Vitányi has been appointed 'Ridder in de Orde van de Nederlandse Leeuw'. He received this royal honour from the Amsterdam alderman Ms. Hennah Buyme during the CWI Lectures in Mathematics and Computer Science on 7 September. Keynote speakers Hendrik Lenstra (Leiden University), Andrew Yao (Beijing University) and Leonid Levin (Boston University) paid a tribute to him. Vitányi (CWI and UvA) received the honour for his excellent scholarship in the field of theoretical computer science. The book that he wrote with Ming Li on Kolmogorov complexity has become an international standard work.

*Paul Vitányi receiving the royal honour from Amsterdam alderman Hennah Buyme*



Photo: CWI



**ERCIM – The European Research Consortium for Informatics and Mathematics is an organisation dedicated to the advancement of European research and development, in information technology and applied mathematics. Its national member institutions aim to foster collaborative work within the European research community and to increase co-operation with European industry.**



**ERCIM is the European Host of the World Wide Web Consortium.**



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<http://www.utia.cas.cz/CRCIM/home.html>



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