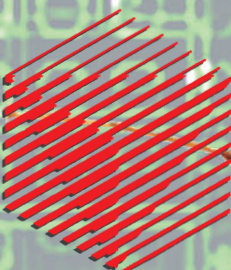


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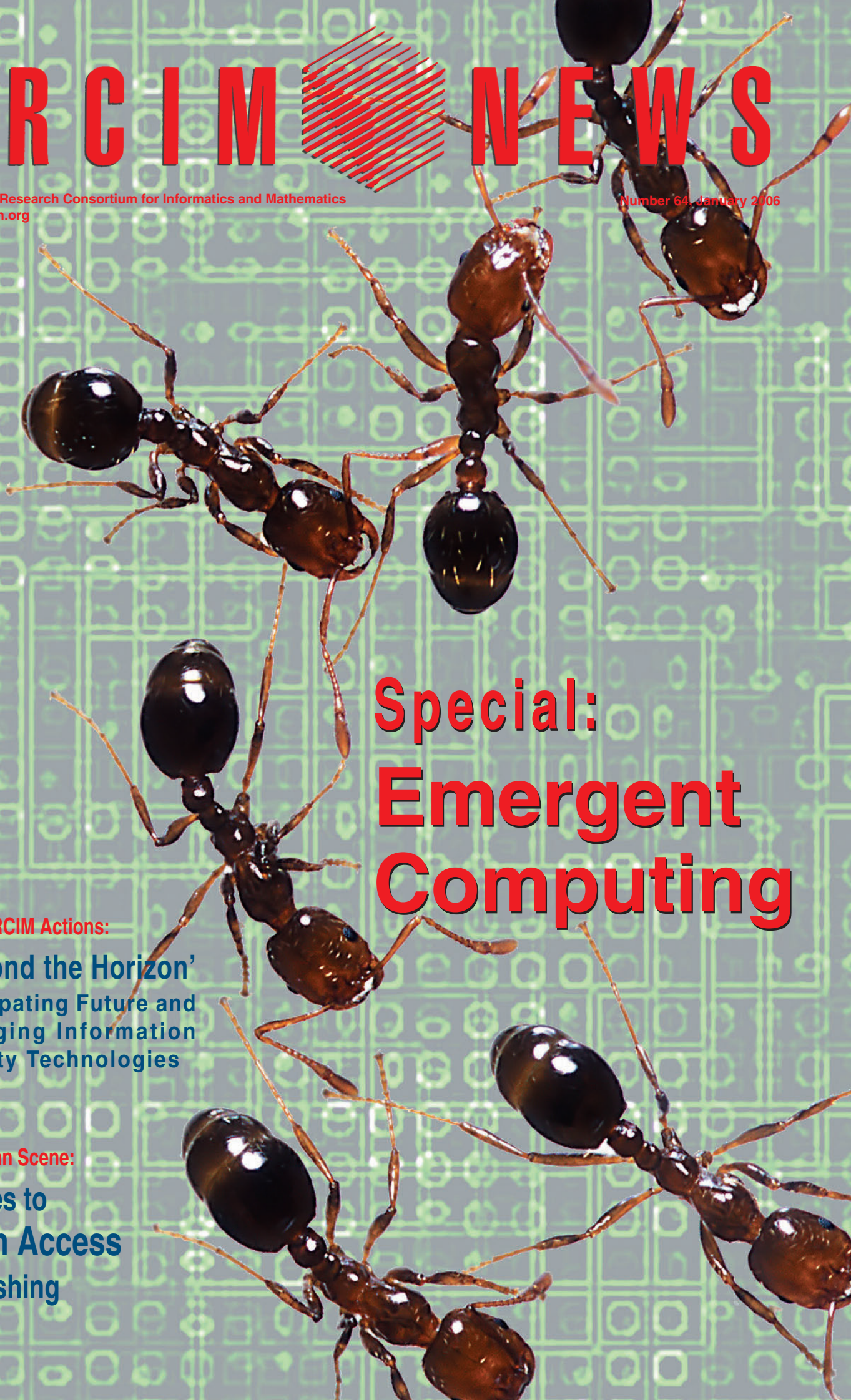
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Fourth ERCIM Soft Computing Workshop

by Petr Hajek

The fourth workshop of the ERCIM Working Group on Soft Computing was held jointly with the conference Logic of Soft Computing IV, held in Ostrava, Czech Republic on 5-7 October, 2005.

The workshop was attended by over 40 scientists from nine European countries and provided an excellent platform for the strengthening of working contacts and exchange of information. Alongside the 29 papers presented, four speakers gave keynote presentations. They were:

- Francesc Esteva, IIIA, CISC, Spain: 'Logics of a Continuous T-norm and Its Residuum with Truth Constants'
- Daniele Mundici, University of Florence, Italy: 'Hajek's Basic Logic and Multi-Channel Games with Lies'
- Umberto Straccia, ISTI-CNR, Italy: 'Fuzzy Description Logics and the Semantic Web'
- Dag Westerstahl, Gothenburg University, Sweden: 'Generalized Quantifier Theory: an (other) Area where Logic Meets Linguistics and Computer Science'.

The local organizer was the Institute for Research and Applications of Fuzzy Modelling, at the University of Ostrava.

Link:

<http://www.cs.cas.cz/ercim>

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Call for Candidates

Cor Baayen Award 2006

The Cor Baayen Award, awarded to a most promising young researcher in computer science and applied mathematics, was created in 1995 to honour the first ERCIM President, and is open to any young researcher having completed their PhD thesis in one of the 'ERCIM countries': Austria, Belgium, Czech Republic, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, Norway, Spain, Sweden, Switzerland, The Netherlands and the United Kingdom.

The award consists of a cheque for 5000 Euro together with an award certificate. The selected fellow will be invited to the ERCIM meetings in autumn 2006. A short article on the winner, together with the list of all candidates nominated, will be published in ERCIM News.

Rules for Nomination

- Nominees must have carried out their work in one of the 'ERCIM countries': Austria, Belgium, Czech Republic, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, Norway, Spain, Sweden, Switzerland, The Netherlands and the United Kingdom
- Nominees must have been awarded their PhD (or equivalent) not more than two years prior to the date of nomination
- A person can only be nominated once for the Cor Baayen Award.

Submitting a Nomination

- Nominations should be made by a staff member of the university or research institute where the nominee is undertaking research. Self nominations are not accepted.
- Nominations must be submitted with an online form
- Alternatively contact the ERCIM Executive Committee member (the national contact point) for the country in which the nominee is undertaking research

Deadline

- Nominations must be submitted by 15 April 2006.

Further information can be obtained from your national contact or from the Cor Baayen Award coordinator László Monostori, SZTAKI, (laszlo.monostori@ercim.org).

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

Result of the 2005 Cor Baayen Award



Milan Vojnovic (right) received the 2005 Cor Baayen Award from the ERCIM president Keith Jeffery at a ceremony during the ERCIM meetings in Louvain-La-Neuve, Belgium on 26 October 2005. Milan Vojnovic, originally from Croatia completed his PhD at Ecole Polytechnique Fédérale de Lausanne (EPFL) in Switzerland and has subsequently worked as an Associate Researcher in the Systems and Networking Group at Microsoft Research in Cambridge.

Winner:

Milan Vojnovic, Microsoft Research, UK

Finalists:

Urtzi Ayesta, France
Francesco Bonchi, Italy
Santiago Escobar, Spain
Marc Esteva, Spain
Keir Fraser, United Kingdom
Emmanuel Frécon, Sweden
Petr Gebousky, Czech Republic
Claudio Mattiussi, Switzerland
Hervé Rivano, France
Fabrizio Silvestri, Italy
Rene Sitters, The Netherlands
Filip Sroubek, Czech Republic
François-Xavier Standaert, Belgium
Martin Svensson, Sweden
Markku Turunen, Finland
Kuldar Taveter, Finland
Kilian Weniger, Germany
Philipp Woelfel, Germany

Second ERCIM Workshop 'Rapid Integration of Software Engineering Techniques'

by Nicolas Guelfi

The Rapid Integration of Software Engineering Techniques (RISE) Working Group held the second edition of its international workshop in Heraklion, Crete, Greece on 8-9 September, 2005. Forty papers were submitted to the workshop, of which nineteen were selected. The proceedings of RISE are expected to be published in the Springer LNCS series (last year's volume was No. 3474).

Six sessions were organized covering many aspects of the integration of complementary mature software engineering techniques. This year we covered areas such as modelling safety case evolution; practical approaches to mapping UML to VHDL; context-aware service composition in pervasive computing environments; techniques for representing product line core assets in MDA/PIM for automation; formal development of reactive fault-tolerant systems; stepwise feature introduction in practice; prototyping domain-specific formal languages; and aspects and contracts.



Second ERCIM RISE Workshop.

The keynote talk was given by Bertrand Meyer, Professor of Software Engineering at ETH Zürich, and Founder and Chief Architect of Eiffel Software in California. He is the inventor of the 'Design by Contract' method, and author of many books, including 'Object-Oriented Software Construction', 'Reusable Software', 'Introduction to the Theory of Programming Languages' and 'Eiffel: The Language'. Both his talk and the discussion it generated were very productive for the workshop.

Last but not least, we thank our Greek partner Anthony Savidis from FORTH, who organized our wonderful stay in Crete.

Link:

RISE homepage: <http://rise.uni.lu>

Please contact:

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Grid@Asia: European-Asian Cooperation in Grid Research and Technology

by Bruno Le Dantec

ERCIM organises the second Grid@Asia Workshop 20-22 February 2006 in Shanghai. The workshop is hosted by the Jiao Tong University. Some 100 participants have been invited from European and Asian research institutes, industry and ministries of research with the aim to foster co-operation with significant Grid actors within the European 6th and 7th Framework Programme (FP).

The workshop will comprise four sessions: the first on applications where Grid technologies play an essential role such as emergency response systems, advanced manufacturing, traffic simulation. The second session will be dedicated to joint research centres involving European and Chinese teams, ie, the Sino-French Laboratory in Computer Science, Automation and Applied Mathematics (LIAMA), the Sino-German Joint Software Institute (JSI) and the Southampton Regional e-Science Centre. The third session will take stock of the existing research projects partially funded by the European Commission and involving Chinese partners. The fourth session will be dedicated to future co-operation emerging from call 5 and 6 of the Information Society Technologies (IST) Programme of FP6.

At the end of the workshop, an 'Information Day' will be organised by the European Commission to promote the IST Call 6 to be closed on 25 April 2006. This call covers the topics 'Ambient Assisted Living (AAL)', 'Advanced Robotics', 'Search Engines for Audio-Visual Content' and 'International Cooperation'.

This workshop is the second of a series of strategic workshops in Asia in the frame of the Grid@Asia initiative supported by the European Commission. The first event took place from 21 to 23 June 2005 in Beijing, hosted by the Beihang University. The aim of the initiative is to expand European Grid expertise through co-operation with leading Asian and international teams in the field.

More information: <http://www.gridatasia.net>

FMICS 2005 — 10th International Workshop on Formal Methods for Industrial Critical Systems

by Mieke Massink and Tiziana Margaria

This 10th edition of the International Workshop on Formal Methods for Industrial Critical Systems (FMICS), a series of workshops organized by the homonymous ERCIM Working Group, was a good occasion to re-examine the use of formal methods in industry over the last ten years, and to outline a promising way forward for the next decade.

For ten years, the FMICS workshops have striven to promote research on and support the improvement of formal methods and tools for industrial critical applications. They are intended to provide a common forum for scientists and industrial professionals to exchange experiences related to the development and application of formal methods. The FMICS Working Group has achieved both broad public visibility and good interaction with the wider scientific community. These merits were recognized by the ERCIM board of directors, which granted the FMICS Working Group the ERCIM award for the most successful Working Group of 2002.

Previous workshops were held in Oxford (March 1996), Cesena (July 1997), Amsterdam (May 1998), Trento (July 1999), Berlin (April 2000), Paris (July 2000), Malaga (July 2002), Trondheim (July 2003) and Linz (September 2004). This year the FMICS workshop was co-located with the European Software Engineering Conference (ESEC) and the ACM SIGSOFT Symposium on the Foundations of Software Engineering (FSE). Together these comprise an internationally renowned forum for researchers, practitioners and educators in the field of software engineering, held in the beautiful city of Lisbon in Portugal. The workshop was organized by the Istituto di Scienze e Tecnologie della Informazione - A. Faedo of Pisa, Italy, and the University of Göttingen in Germany. Thirty participants from academia and industry from about thirteen countries attended the workshop.

Fourteen contributions were selected from 27 good-quality submissions, covering both industrially relevant theoretical topics as well as industrial case studies.

Two invited speakers gave excellent presentations. Giorgios Koutsoukis, replacing Luis Andrades from ATX Software SA, Lisbon, gave a presentation on the experience of ATX with the application of formal and rigorous techniques and methods in real projects. Christel Baier from the University of Bonn gave a presentation on the most recent developments in the quantitative analysis of distributed randomized protocols.

A special session was arranged for the presentation of a follow-up to the much cited and widely discussed article 'Ten Commandments of Formal Methods' by Jonathan P. Bowen and Michael G. Hinchey, which was published ten years ago. Both authors joined the workshop to present a perspective on ten years of the industrial application of formal methods, and set the stage for a lively discussion on progress in the decade to come. The organizers are very happy that both authors chose the FMICS workshop as the forum in which to present their new ideas.

The award for the best paper was granted this year to de la Camara, Gallardo, Merino and Sanan for their excellent paper on the application of model checking to distributed software systems that use API Sockets and the network protocol stack for communications. The award was granted with the support of the European Association of Software Science and Technology (EASST). Other papers presented at the FMICS05 workshop included 'An Approach to the Pervasive Formal Specification and Verification of an Automotive System', 'Developing Critical Systems with PLD Components', 'Test Coverage and System Development Based on Lustre', 'Integrated Formal Methods for Intelligent Swarms' and many others.



Pedro Merino Gomez, University of Malaga, Spain, giving a presentation of his paper during the workshop. He received the 2005 EASST best-paper-award. Pedro Merino Gomez has been elected the next chair of the FMICS working group.

The proceedings of the workshop were published as ACM-SIGSOFT paper proceedings and have also appeared in the ACM Digital Library. Selected papers will be invited for publication in a special issue of the International Journal on Software Tools for Technology Transfer.

The organizers wish to thank ESEC/FSE for hosting the FMICS05 workshop and taking care of many administrative aspects, ACM SIGSOFT for their sponsorship and ERCIM for its financial support of the workshop. Additionally, the organizers would like to thank EASST (European Association of Software Science and Technology), ATX Software, and the institutions CNR-ISTI and the University of Göttingen for supporting this event.

Link:

FMICS Working Group:
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Bits, Atoms and Genes Beyond the Horizon

by Dimitris Plexousakis

The 'Beyond the Horizon' Project invites the research community in Europe to participate in defining research themes on Future and Emerging Information Society Technologies in the Seventh Framework Programme

In order to achieve the full potential of the Information Society and to ensure the long term competitiveness of Europe, vigorous R&D activities in Information and Communication Technologies (ICTs) and related disciplines are essential. This is the key role of the Information Society Technologies (IST) programme within the forthcoming 7th Framework Programme. As part of IST, the Future and Emerging Technologies (FET) activity has the role of stimulating the emergence and development of new IST-related disciplines and technologies, which promise to have significant scientific, industrial and societal impact. In this perspective, FET is supporting long-term, visionary, high-risk collaborative basic research projects in advanced strategic research areas related to ICTs.

Further advances in ICTs are increasingly relying upon their synergy and cross-fertilisation with other scientific and technological fields. For example, we can see prospects in the miniaturisation of ICT devices compatible and interacting with living organisms, also allow-

ing to invent ICT components and systems based on synthetic bio-molecular structures and beyond this, systems able to physically grow and self-repair. New computing and communication schemes are increasingly inspired by our burgeoning new understanding of the living world. New simulation tools and systems are being developed to model the living

Participate in the Europe-wide consultation process that ERCIM is organising in close collaboration with European S&T communities in order to define the major challenges and promising research directions that FET could support in the forthcoming Seventh Framework Programme.

Visit <http://www.beyond-the-horizon.net>

world from molecules to cells, organs, organisms and societies, and, for example, to predict effects of medicines or model the integration of artificial organs with living organisms.

This is particularly true between ICTs, new materials, biology and the life sciences, where progress in nano- and information technology is blurring the

boundaries between information, material and life. In the coming decades, this cross fertilisation will intensify as scientists from different disciplines learn from each other's different ways of thinking.

Providing Input for FP7

Beyond-The-Horizon (B-T-H) is a coordination action funded by IST-FET and coordinated by ERCIM. The purpose of this project is to define major challenges and promising research directions that FET could support in the forthcoming FP7 in ICT-related strategic basic research areas. Through an extensive and systematic consultation of the relevant science and technology communities in Europe, the project will deliver innovative, visionary and interdisciplinary research directions and plans that would permit to develop future ICT-related technologies and their impact on society over the next 15 years. Six individual strategic research fields as well as their cross-links are the foci of the action, namely: 'Pervasive Computing and Communications (Thematic Group 1 or TG1)', 'Nanoelectronics and Nanotechnologies (TG2)', 'Security, Dependability and Trust (TG3)', 'Bio-ICT Synergies (TG4)', 'Intelligent and Cognitive Systems (TG5)' and 'Software Intensive Systems (TG6)'.

Throughout the year 2005, the six thematic groups have held brainstorming workshops for the purpose of identifying the emerging grand challenges in the respective areas. The workshops brought together eminent researchers from both academia and industry that embarked on drafting agendas for basic research in the six thematic areas. Summaries of the findings of the groups are reported in short articles in this issue. More detailed reports are available through the project's web site. The reports will be finalized in the next few months, after a wider



Key speakers at the plenary workshop. From left: Gavriel Salvendy, Purdue University, USA and Tsinghua University, China; Claude Cohen-Tannoudji, Ecole Normale Supérieure, Paris, Winner of the 1997 Nobel Prize in Physics; Keith Jeffery, Director for IT of CCLRC and ERCIM president; and Thierry Van der Pyl, Head of Unit, Future and Emerging Technologies, European Commission.



consultation with the relevant European research communities that will start soon.

Plenary Workshop

A Plenary Workshop in Paris, 12-13 December 2005 brought together representatives of the six aforementioned thematic groups for the purpose of examining and consolidating the research challenges and themes that were identified at the individual workshops and of exploring new promising research challenges that arise at the intersections of the different areas. The debates were enriched with varying perspectives by notable invitees from the European research community, including members of the IST Committee and representatives of the French Ministry for Research. Other workshop special guests included Claude Cohen-Tannoudji, Winner of the 1997 Nobel Prize in Physics; Wendy Hall, representative of the future European Research Council; Anne Cambon-Thomsen, member of the European Group on Ethics. Keith Jeffery, President of ERCIM; and, Ulf Dahlsten, IST Director, and Thierry Van der Pyl, IST-FET Head of Unit, European Commission. Prof. Gavriel Salvendy (Purdue University, USA and Tsinghua University, China) shared an 'outsider's view' on the directions of basic research in ICTs. The workshop was very well-attended (80 delegates) and the discussion sessions were lively. The complete programme, presentation slides and photographic material are available through the project web site.

B-T-H is now entering its second stage during which the Thematic Group reports are disseminated to the European research community at large for feedback and consultation. The reports are accessible through the action's web site. Research communities in Europe are invited to provide their comments through the on-line consultation mechanism on the B-T-H website.

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Thematic Group 1: Pervasive Computing and Communications

by Alois Ferscha

The vision impacting the evolution of Pervasive Computing and Communications is that of an intuitive, unobtrusive and distraction-free interaction with technology-rich environments. In an attempt to bring interaction 'back to the real world' after an era of keyboard and screen interaction, computers are being understood as secondary artefacts, embedded and operating in the background, whereas the set of all physical objects present in the environment are understood as the primary artefacts, the 'interface'. Instead of interacting with digital information via traditional computing means, Pervasive Computing aims at physi-



Pervasive Computing – state of the art.

cal interaction with digital information, ie, interaction by manipulating physical artefacts via 'graspable' interfaces. It links the 'atoms of the physical world' with the 'bits of the digital world' in such a way, that every physical artefact is considered as being both representation of and control for digital information.

The challenges of Pervasive Computing are dominated by the ubiquity of a vast manifold of heterogeneous, small, embedded and possibly mobile artefacts, the evolvability of their population, functionalities and interoperation, the ability of perceiving and interpreting their situation, the autonomy of their goal-oriented behaviour, the dynamicity and context-adaptation of services offered, the ad-hoc interoperability of services and the different modes of interaction

of people with these devices and the services they offer (see Figure).

Proposed Research Themes

In order to address the above, experts participating in TG1 agreed to structure the final research agenda along the following three visionary challenges: 'Networked Societies of Artefacts', 'Evolve-able Systems', and 'Human Computer Confluence'.

The key technical problems and milestones that must be solved towards achieving this vision are summarised as follows:

1. Networked Societies of Artefacts

- deriving models for goal-oriented and social behaviour
- enhancing and enriching the communication fabric of societies, eg enabling opportunistic networks
- harnessing dispersed content and managing information
- designing and developing space aware models.

2. Evolve-able Systems

- the development of viable, evolve-able systems (hardware, software, communication fabric)
- enabling the autonomic adaptation to unforeseen situations, interpreting context, and creating future aware behaviour in support of both, long-term forward evolution as well as short-term adaptivity and self-properties
- considering deterministic, nondeterministic and bio-inspired paradigms, including stochastic approximation,
- coping with the fundamental issue of scale.

3. Human Computer Confluence

- supporting invisible, implicit, natural, embodied, and even implanted interaction,
- considering qualitative aspects such as user experience and user behaviour.

Participate in the online consultation of this report from 1 February to 31 March 2006 at <http://www.beyond-the-horizon.net>

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Thematic Group 2: Nanoelectronics and Nanotechnologies

by Colin Lambert

Experts participating in this thematic group recommend sustained investment in research to underpin the 'More of Moore', 'More than Moore' and 'Beyond Moore' technology drivers:

- The 'More of Moore' approach is focused on delivering the 'International Technology Roadmap for Semiconductors' (ITRS) for late complementary metal oxide semiconductor (CMOS) and post-CMOS systems, and in particular, how to continue Moore's law beyond the predicted 22 nm node in 2011.
- The 'More than Moore' approach is focused on delivering greater functionality through heterogeneous integration of nanosystems with electronic, optical, magnetic, chemical, biological, mechanical and other functions: Research themes which extend 'Beyond Moore' in terms of their potential to deliver disruptive technologies include new paradigms such as intra-molecular computing and solid-state quantum information processing (SSQIP), addressing the emerging field of engineering coherent solid-state quantum systems.

Future disruptive technologies and breakthroughs are likely to come from progress in a range of rapidly-developing areas. The medium-term impact of many of these technologies may initially occur in niche 'More than Moore' areas, which would provide economic benefits and stimuli before impacting on the 'More of Moore' or "Beyond Moore" challenges.

Proposed Research Themes

The following promising research themes were identified by experts of this Thematic Group:

1. 'System-ability' of emerging ICT technologies and devices, involving multi-disciplinary teams of system architects and nano-technology researchers. This research would link system-level objec-

tives such as high performance, reliability, correctness, ease of programming, to developments of advanced, potentially interfering or unreliable nanoscale-devices. An important element is to build suitable simulation methods and design tools that link nano-scale device models with higher-level heterogeneous system design environments

2. *Interfacing nano-scale biology with nano-electronics*, including bio-nano transduction and growable electronics. This would provide the basic hardware structures to develop research objectives under B-T-H TG5 (Intelligent and Cognitive Systems) and could lead to circuits and connections which grow, shrink or reconfigure according to demands on functionality, thereby impinging on activities in TG2 involving evolvable hardware and emergent design.

3. *Future interconnects for heterogeneous system integration*. Objectives include higher integration density, less I/Os, shorter wires, lower power dissipation and higher speed. Promising research directions include the use of nanotubes, nanowires, recently-synthesised molecules, nonlinear wave propagation and 3d architectures. Another direction is to emulate natural systems such as nerve bundles, which show an example of unidirectional, self-restored signal propagation, chemically assisted guided growth and life-long repair capability. To avoid problems associated with high-density interconnects, non-local processing in non-charge-based devices and interconnect-lean architectures such as cellular automata could also be explored.

4. *Post-CMOS memory, storage and logic*, aimed at identifying nano-devices that integrate gracefully with CMOS and architectures that exploit the advantages of both CMOS 'hosts' and these new nanotech blocks. The research would investigate a range of information carriers such as electrons, spins, photons, phonons, atoms, molecules, mechanical state and material phase.

5. *Nanoelectromechanical systems (NEMS)*, including VLSI-like arrays of sensors, probes and sources and nano-object-based NEMS with potential

applications to microwave signal processing, mechanically detecting magnetic resonance imaging, bio-sensors and bio-actuators, micro-nanofluidics, single molecule sensing and-analysing, data storage and operation at the quantum limit.

6. *Nanotechnologies for quantum-coherent systems*, aimed at exploiting quantum effects in solid state devices. It includes investigating new types of solid-state qubits and scalable coherent systems to build large-scale coherent systems and practical quantum computers, and at addressing the ambitious materials science challenges associated with the engineering of solid-state qubits and quantum coherent systems in solid-state environments.

Participate in the online consultation of this report from 1 February to 31 March 2006 at <http://www.beyond-the-horizon.net>

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Thematic Group 3: Security, Dependability and Trust

by Michel Riguidel

ICT security balances freedom and the desire to protect tangible and intangible assets, ensures the immunity of applications and system resilience, and instils and preserves confidence in digital, critical infrastructures. At the smallest level, nanotechnology, quantum communication and cryptography offer new opportunities to tackle ICT security.

Embedded sensors and devices can form ad-hoc networks requiring new mechanisms for establishing trust when sharing information or resources. New paradigms come to the foreground, such as service architectures that compose services from lower level modules, peer-to-peer systems characterized by their remarkable robustness and resilience against attack, and biological defence



mechanisms which may inspire new breakthrough technologies. At a larger scale, the completion of the Galileo satellite navigation system around 2009 will create ever more sophisticated possibilities for positioning with implications for both security and privacy.

Proposed Research Themes

In view of the above, the following emerging research themes were identified by experts participating in this Thematic Group:

1. Ambient Trustworthiness

The mass diffusion of digital systems must be enabled with built-in mechanisms for enhancing trust and confidence on their usage. Common security mechanisms mainly based on boundaries and firewall protection mechanisms do not scale with respect to new complex systems. We should imagine different mechanisms such as the ones inspired by the living world: immune and self-healing systems. We should consider autonomous, evolvable and adaptive security mechanisms, which will require new semantic models managing the complexity of ambient intelligence environments where humans and devices may jointly function and interact. Security systems and cryptographic mechanisms must be scaled down for inclusion in small devices (even at nano-scale) with specific requirements for energy consumption and computation power.

2. Dynamicity of Trust

Lack of trust either on the cyber-infrastructure (due to frequent attacks) or the difficulties to model trust relationships among different entities (human and digital ones) is one of the main barriers for the establishment of a true Information Society. In future ICT systems with billions of interconnected devices, the capability of managing and negotiating trust relationships that foster cooperation is crucial. The understanding of how trust emerges and evolves, as well as of the related notions of reputation formation, monitoring and evolution are mandatory. Security-based trust and trust-based security are two emerging areas of interest. A deeper understanding of trust needs the involvement of research expertise from several fields such as economy and sociology.

3. Quantum Technology and Cryptography

Nature can provide us with resources to secure our information and communication systems. The possibility provided by Quantum technology to offer secret bits of information among authenticated distant partners, as well as truly random values, could serve as building blocks of many protection mechanisms. Quantum technology and quantum computing might also represent a major threat for current cryptographic algorithms and mechanisms. We should also study the assumptions under which Quantum Computers (QC) may act and their consequences on current and future cryptographic methods, as well as the development of new QC resistant cryptographic techniques.

4. Assessability and Verifiability

Assessing and proving the trustworthiness of a complex system is a major issue. During the last years many techniques have been developed, especially in the dependability community. Yet, the scale of new ICT systems and the kind of threats and assumptions about their operational environment pose new challenges. Different metrics, modelling tools and observation mechanisms are needed. The capability of measuring the tolerance to attacks is crucial in new systems that due to their logical and physical diffusion are susceptible to 'attack'. There is a need to develop a discipline of software and system security based on high-level verifiably secure programming. This calls for an approach based on efficiently verifiable mathematical proofs showing compliance to policies (expressing safety, security, or functionality constraints).

Participate in the online consultation of this report from 1 February to 31 March 2006 at <http://www.beyond-the-horizon.net>

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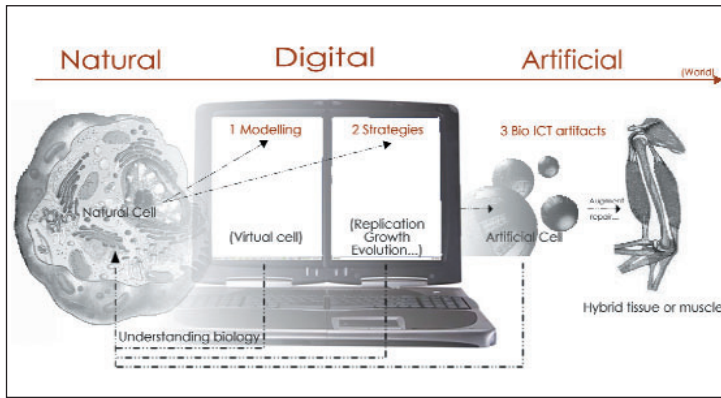
Thematic Group 4: Bio-ICT Synergies

by Fernando Martin-Sanchez

The prospect of having ICTs that would be more life-like and thus for instance more robust, self-regulating, adaptive, evolving, environment friendly and easy to live with, has long stimulated computer scientists to look for inspiration in the biological domain. Most bio-inspired ICT techniques and methods were designed on the basis of biological knowledge available at the '80s. In the meantime, biology has brought a wealth of new knowledge – for instance on development, action, perception, homeostasis and learning – that can now be exploited to fuel further advances in ICT systems. Conversely, efficient algorithms can be used to reflect back to biology, for instance to enable more efficient drug design, to move toward personalized medicine, or to distill a more synthetic view of the biological field. Beyond such cross-fertilization, however, maturing technologies and knowledge from both sides are paving the way for a deeper convergence between the biological and the ICT domain which will lead to systems with tightly integrated biological and technological components and to radical innovations, for instance in computer architectures, interfaces, prosthesis and implants.

The aim of this thematic group is to identify a long-term research agenda that would unlock the full potential of Bio-ICT synergies over the next few decades. How can we meaningfully combine biological and technological perspectives and exploit what is learned to advance both biology and technology, effectively linking the realms of information, material and life? The vision of technology becoming like a 'second nature' would have tremendous social, economic and industrial impact. Not only would it lead to new types of computational hard- and software; it would also improve, among others, manufacturing, medicine, the energy sector and the quality of the environment and of life in general. This will require radical interdisciplinarity, including the whole range of life sciences, but also the nano- and neuro-sci-

Connecting the natural, digital and artificial worlds: cell modelling, synthesis and hybrid systems.



ences. This being said, this group emphasises the ethical dimension of the vision, as well as the well known but unresolved difficulty of genuine multi-disciplinary research as key extra-scientific hurdles to be addressed.

Proposed Research Themes

Three main research themes were identified as pillars for exploiting the Bio-ICT synergies potential, namely 'New Computational Modelling Paradigms', 'Bio-Inspired Strategies of Growth, Adaptation and Evolution' and 'Bio-ICT Artefacts' (see Figure).

1. New Computational Modelling Paradigms

A major research challenge is the formalization and development of computational paradigms that are capable of capturing, relating and integrating the different levels of complexity in biological systems - from the molecule to the cell, tissue, organ, system, individual, population and ecosystem. Some of the technical challenges involved are: (a) connecting models at different levels of abstraction, (b) connecting discrete with continuous models, (c) dealing with inconsistent, competing models and (d) fitting models to data (data driven modelling). Other than contributing to systems biology, this research would lead to new computational architectures inspired by natural information processing structures eg in the brain or molecular processing within the cell, but applicable in different domains than the biological ones.

A thorough understanding of information processing in biological systems would lead to new computing systems based on 'wet-ware' or other life-like hardware, consisting of very large numbers of sim-

ple devices operating in a highly parallel fashion at comparatively low speed and with very low power dissipation.

2. Bio-Inspired Strategies of Growth, Adaptation and Evolution

In contrast to technological systems, biological systems have extraordinary capability to change over time. They grow, adapt, self-assemble, replicate, heal, self-organise, evolve. The second theme thus concerns studying how technological systems can grow, change, adapt, organise, heal and evolve to match, over long periods of time, evolving needs whilst being compatible with natural processes of change that surround them, for instance when dispersed in the environment, or when implanted. These different strategies of change are not independent but operate at different time scales and either at the individual or population level. We propose an interdisciplinary exploration of adaptation, learning, self-organisation, evolution and other emergent functionalities of living systems for the design of new computing models, algorithms and software programming paradigms. Moreover, there is enormous potential for applying this at the physical level, in particular at the nano- and micro scale, to develop new types of growing and evolving hardware (eg, memory or computing capacity grows when needed) and intelligent materials that could be applied in a variety of ambient interfaces.

3. Bio-ICT artefacts

The third theme of research in modelling both the organizational and phenomenological features of living systems is to seamlessly integrate artificial entities into biological systems and processes (classical examples include artificial retinas or physiologically coupled arti-

cial limbs). In this sense, main challenges include: (a) developing new information theories and modelling techniques to capture how biological systems realise basic capabilities of living systems at different granularities, (b) developing ways to validate such theories with respect to real biological systems, (c) interfacing between the living and the artificial world, including restoration or substitution of human capabilities (eg, using implants), (d) providing sensor/motor interface to the body, (e) extending the range of capacities beyond perception and action, including for instance memory, resistance to bacteria and viruses, or interfacing directly in metabolic processes ('cyber-drugs').

Participate in the online consultation of this report from 1 February to 31 March 2006 at <http://www.beyond-the-horizon.net>

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Thematic Group 5: Intelligent and Cognitive Systems

by Rolf Pfeifer and Alois Knoll

The grand challenge is that of building intelligent and cognitive systems that are capable of acting in the real world and interacting with humans in natural ways.

A promising research area tackling this challenge is the development of so-called complete agents, that is, agents that are embodied and self-sufficient (ie, they can sustain themselves over extended periods of time), situated (ie, they can acquire information about the environment through their own sensory systems), and autonomous (ie, they function independently of external control). For 'intelligent and cognitive systems', participants in this thematic group recommend to focus research efforts within the framework of embodiment. In this framework, intelligence and cognition are properties that emerge as an agent interacts with its environment.



Proposed Research Themes

In order to meet the above long-term challenge, the following research themes need to be pursued:

1. Mind-Body Co-Development and Co-Evolution

In order to maximally exploit the design power of evolution and development, controllers and robot morphologies have to evolve simultaneously. The permanent interaction of the body of an agent with the environment during growth enables its 'mind' to develop. We need to understand and model developmental processes in nature and build embodied artificial systems that are inspired by them; embed them into evolutionary processes, and study interaction of physical and information processes during this development. These also require physical growth (see the following point).

2. Systems and Materials that can Physically Grow

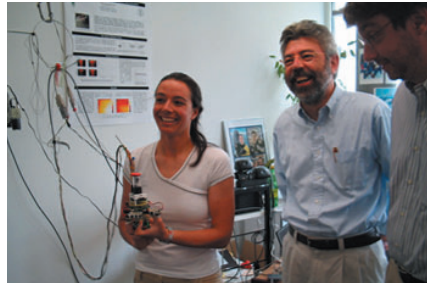
Recent research strongly suggests that physical instantiation and materials play an essential role in system behaviour. Also, through growth, biological organisms can form highly complex morphological structures. In this respect there are promising starting points (eg, modular robotics, self-assembling materials, etc). Although it is not expected to have growable materials that match biological capacities available any time soon, some aspects of physical growth can be studied through advanced principles of autonomous modular systems that optimally adapt to a task and the environment.

3. Morphological Computation

Shape and the materials (eg, muscles) perform important functions for an agent in real time, an idea that bypasses the concept of classical Turing computation architecture. Morphological computation here refers to processes based on shape (eg, molecules/DNA, modules of a modular robot, shape of a limb) and material properties (eg of the muscle-tendon system). The challenge will be to explicitly apply morphological concepts in theoretical and practical explorations of embodied artificial systems.

4. Design for Emergence

As behaviour is always the result of the



Task Group 5 workshop participants Giulio Sandini and Olaf Sporns learn about the artificial whisker system developed by Miriam Fend of the Artificial Intelligence Laboratory in Zurich in the IST-FET-funded Artificial Mouse Project (AMouse, <http://www.amousse.de/>).

interaction of an agent with the environment, behaviour is emergent, meaning that it cannot be understood (and designed) on the basis of the internal control program (or 'brain') only. The question then is: how can we design purposive (goal-directed) agents without destroying the emergent nature of their behaviour?

In each of these research areas real physical embodiment plays an essential role. Simulation work ('embodied agent simulations') could form an important part of the endeavour.

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Thematic Group 6: Software-Intensive Systems

by Martin Wirsing

Software has become a central part of a rapidly growing range of applications, products and services from all sectors of economic activity. Systems in which software interacts with other software, systems, devices, sensors and with people are called software-intensive systems. Examples include large-scale het-

erogeneous systems, embedded systems for automotive and avionics applications, telecommunications, wireless ad hoc systems, business applications with an emphasis on web services etc.

Our daily activities increasingly depend on complex software-intensive systems that are becoming ever more distributed, heterogeneous, decentralized and inter-dependent, and that are operating more and more in dynamic and often unpredictable environments. These trends will continue to amplify in the future, while requirements for quality of service, security, and trust will dramatically increase. Current engineering methods and tools are not powerful enough to design, build, deploy, and maintain such systems. Moreover, to continue to work dependably with them, such systems would have to exhibit adaptive and even anticipatory behaviour. Today's grand challenge is to develop practically useful and theoretically well-founded principles, methods, algorithms and tools for programming and engineering such future software intensive systems throughout their whole life-cycle.

Proposed Research Themes

Among the many promising areas for future research, the participants in this Thematic Group have identified three crucial areas: Engineering adaptive software-intensive systems; managing diversity in knowledge; and eternal software-intensive systems.

1. Engineering Adaptive Software-Intensive Systems

The current approach, where systems are mainly assembled at design time does not scale to pervasive, highly dynamic systems. The emergent behaviour of systems is an unavoidable fact that must be exploited during the system's life time, in order to scale to the level of complexity we are witnessing. Systems will no longer be produced ab initio, but more and more as compositions and/or adaptations of other, existing systems, often performed at runtime as a result of a process of evolution. The challenge is to develop algorithms, methods, tools and theoretical foundations that enable effective design

by harnessing, controlling and using the effects of emergent system properties.

2. *Managing Diversity in Knowledge*

We are facing an unforeseen growth of the volume and complexity of the data, content and knowledge being produced. In knowledge management and engineering, the 'usual' approach is to take into account, at design time, the possible future dynamics, most commonly by designing a global reference representation schema and by codifying into it all the possible diverse knowledge components. As applications become more and more open and complex, this top-down approach shows its limits. We need a new, bottom-up, approach for managing knowledge where the different knowledge parts are designed and kept 'locally' and independently and where new knowledge is obtained by the design- or run-time adaptation of such different knowledge parts. This calls for developing adaptive or even self-adaptive knowledge systems that are able to manage diversity in knowledge by harnessing, controlling and using the effects of emergent knowledge properties.

3. *Eternal Software-Intensive Systems Information*, and the tools to work with it, represent one of society's most important assets. From a cultural as well as an economic point of view, it is essential to enable continuous and up-to-date access to long-lived and trustworthy information systems, as well as to guarantee that the corresponding information systems do not age and break but are able to preserve and update their original functionality and properties in a machine independent way by re-programming themselves to take into account new contexts. In other terms, the challenge is to organize software-intensive systems so that they can survive and evolve in a constantly changing world.

Participate in the online consultation of this report from 1 February to 31 March 2006 at <http://www.beyond-the-horizon.net>

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Quantum Information Processing and Communication

Preparation for FP7 in Future and Emerging Technologies Unit, DG INFSO, EC

In view of the forthcoming FP7, the Unit Future and Emerging Technologies (FET) of DG Information Society and Media is now carrying out a Europe-wide consultation process with the relevant S&T communities in a number of ICT fields. The objective is to define the major challenges and promising research directions that FET could support in FP7 (see B-T-H articles in this issue).

Quantum Information Processing and Communication (QIPC) is now a well established scientific field which opens unconventional perspectives for information processing. It exploits fundamentally new modes of computation and communication with the aim to understand the quantum nature of information and to learn how to formulate, manipulate, and process it using physical systems that operate on quantum mechanical principles (control of coherent superpositions of quantum degrees of freedom – qubits). Today, there is a significant world-wide effort to advance research in QIPC, which has led to a deeper and broader understanding of information theory, of computer science and of the fundamental laws of the quantum world. Advances in QIPC could soon lead to new technologies and devices that hold the promise to radically change the way we compute and communicate.

Since its early steps, European scientists have been at the forefront of QIPC research. So far, FET is the sole part of the IST Programme that has been supporting QIPC research and has been very successful in attracting the best research teams in Europe. While the field has now reached a certain degree of maturity and there is critical mass in Europe in the main sub-fields, it is still necessary to further expand and strengthen activities at the European level. In view of the forthcoming FP7, FET and the European QIPC research community have actively been working during the last year towards the elaboration of a common European research strategy in the field. These efforts have culminated in the publication of a technology roadmap on 'Quantum Information Processing and Communication: Strategic report on current status, visions and goals for research in Europe'. This report was written by the most prominent scientists in the field and, after a wide consultation within the QIPC research community, it is now published on the FET web site (<http://www.cordis.lu/ist/fet/qipc.htm#prepf7>).

The QIPC roadmap presents in a comprehensive way the state-of-the-art, the medium and long term goals and the visions and challenges for the future. It includes an overview of FET activities, a description of national research programmes and the worldwide research position of Europe in QIPC. The main bulk of the document is devoted to a scientific assessment of current results and an outlook of future efforts. It covers three main research directions: quantum communication, quantum computing and quantum information science, as well as the interactions and interdependences between them. The document stipulates the need for further support in these three research directions, as well as to keep a diversity of experimental realizations and to look for synergies between them in order to reach concrete objectives. Integration across different disciplines and between different experimental approaches is considered crucial for the further advancement of QIPC in Europe. Prospects for applications and commercial exploitation are equally discussed. The roadmap is a living document, which will be periodically updated in order to serve as a guideline both to scientists and decision makers.

In parallel to the strategic report, the research community in collaboration with FET has produced the publication "QIPC in Europe". It is a collection of 30 articles in "Scientific American" style written by 58 of the most prominent experts in Europe. It gives a balanced overview of QIPC research in Europe and refers to work accomplished within FET and nationally funded projects. These two documents complement each other and are important milestones along the way towards elaborating a common European strategy in QIPC. They are both published in the FET QIPC proactive initiative web site and by the Publications Office of the European Commission.

Link: <http://www.cordis.lu/ist/fet/qipc.htm>

The Web on the Move

Successfully attended with over 150 participants, the first outreach public Mobile Web Initiative (MWI) event, held in London on 15 November 2005, focused on current mobile Web challenges and opportunities. The program opened with a video welcome from Tim Berners-Lee, followed by a presentation on the vision and ambitions for the mobile Web by Philipp Hoschka, Deputy Director for W3C Europe and W3C's Mobile Web Initiative leader.



Mobile Web Initiative (MWI) event in London.

Mobile Web Initiative sponsors were present on two panels: 'Mobile Web Challenges and Potential' and 'Putting the Vision into Practice', chaired respectively by Rotan Hanharan, chief architect at MobileAware, and Daniel Appelquist, senior technology strategist for the Vodafone Group. All presentations are linked from the agenda available on the event home page.

The mobile Web goes where the users go. Instead of running back to their computer for Web access, users will now have Web access when and where they need it, using their mobile device. To that effect, Mobile Web Initiative (MWI) participants are building a database of device descriptions and developing best practices for the creation of mobile friendly Web sites.

MWI is led by key players in the mobile production chain, including authoring tool vendors, content providers, handset manufacturers, adaptation providers, browser vendors and mobile operators. Current MWI sponsors are: Ericsson, France Telecom, HP, Nokia, NTT DoCoMo, TIM Italia, Vodafone, Afiliat, Bango.net, Drutt Corporation, Jataayu Software, Mobileaware, Opera Software, Segala M Test, Sevenval AG, Rulespace and Volantis.

Links:

MWI UK event: <http://www.w3.org/2005/11/mwi-ukevent.html>

W3C Mobile Web Initiative: <http://www.w3.org/Mobile/>

W3C to Internationalize and Secure Voice Browsing

Following the successful technical Workshop held in Beijing last November 2005, and taking into account valuable inputs from the VoiceXML Forum, the W3C announced new work on extensions to components of the Speech Interface Framework which will both extend Speech Synthesis Markup Language functionality to Asian and other languages, and include speaker verification features into the next version of VoiceXML, version 3.0. Addressing both areas expands both the reach and functionality of the framework.

The Speech Synthesis Markup Language (SSML), a W3C Recommendation since 2004, is designed to provide a rich, XML-based markup language for assisting the generation of synthetic speech in Web and other applications. The essential role of the markup language is to provide authors of synthesizable content a standard way to control aspects of speech such as pronunciation, volume, pitch, rate, etc. across different synthesis-capable platforms.

While these attributes are critical, additional attributes may be even more important to specific languages. For example, Mandarin Chinese, the most widely spoken language in the world today, also has the notion of tones - the same written character can have multiple pronunciations and meanings based on the tone used. Given the profusion of cellphones in China - some estimate as high as over one billion - the case for extending SSML for Mandarin is clear in terms of sheer market forces. Including extensions for Japanese, Korean and other languages will ensure that a fuller participation possible of the world on the Web.

Users of telephony services and the Web are also demanding speaker verification. Identity theft, fraud, phishing, terrorism, and even the high cost of resetting passwords have heightened interest in deploying biometric security for all communication channels, including the telephone. Speaker verification and identification is not only the best biometric for securing telephone transactions and communications, it can work seamlessly with speech recognition and speech synthesis in VoiceXML deployments.

Link:

Voice Browser Activity: <http://www.w3.org/Voice/>

Call for Participation

W3C Workshop: 'Toward a More Secure Web'

New York City, USA, 15-16 March 2006

Web security today critically depends on Transport Layer Security (TLS), an IETF protocol that is wrapped around HTTP transactions to provide endpoint authentication and communications privacy. Ongoing 'phishing' attacks demonstrate that these security measures fail in practice: while the currently available mechanisms are technically solid, implementations often don't succeed in making users aware what kind of security is actually in place, and with whom they are actually communicating. As a result, attackers can bypass these security mechanisms without users noticing.

This Workshop aims to concretely identify a range of issues faced by those who wish to use the Web as a secure environment for tasks ranging from basic browsing to the most specialized application. In particular, the participants will look at ways to help address the current threats on the Web that are caused by the present lack of comprehensible and transparent Web authentication. The Workshop is expected to focus on near-term improvements that can be realized in browsers and through best practices coordinated between browser vendors and e-commerce service providers. Experiences and use cases from the financial services industry are expected to inform the discussion.

The Call for Participation solicits position papers from Web security experts, software developers, browser manufacturers and their customers regarding usability and transparency of Web authentication. The goal is to identify methods to make secure, trustworthy browsing easy.

The Workshop is chaired by Daniel Schutzer (Citigroup), and Thomas Roessler (W3C). Position papers can be submitted by email until 25 January 2006. The Workshop takes place in New York City, USA, on 15 and 16 March 2006, and is hosted by Citigroup.

Links:

Workshop: <http://www.w3.org/2005/Security/usability-ws/>
Call: <http://www.w3.org/2005/Security/usability-ws/cfp.html>

Latest W3C Recommendation

- Synchronized Multimedia Integration Language (SMIL 2.1) 13 December 2005, Dick Bulterman, CWI, Guido Grassel, Nokia, Jack Jansen, CWI, Antti Koivisto, Nokia, Nabil Layaïda, INRIA, Thierry Michel, W3C, Sjoerd Mullender, CWI, Daniel Zucker, Access Co., Ltd.

A complete list of all W3C Technical Reports:

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

W3C Continues ICANN Participation

W3C is pleased to announce the nomination of Daniel Dardailler, W3C Associate Chair based in Europe, as W3C liaison to the Internet Corporation for Assigned Names and Numbers (ICANN) Board of Directors. Thomas Roessler will serve on the 2006 ICANN Nominating Committee (NomCom). W3C's involvement in ICANN and in the post-WSIS forum, soon to be launched, should help preserve the operational stability of the Internet and the Web in a transparent and open way while ensuring its unfragmented growth based on contributions from the international community.

Call for Participation

Workshop on the Ubiquitous Web

Position papers are due 10 February for the W3C Workshop on the Ubiquitous Web to be held 9-10 March 2006, hosted by Keio University in Tokyo, Japan. The 'Ubiquitous Web' seeks to fulfill the potential of the Web for distributed applications that adapt to the user's needs, device capabilities and environmental conditions.

Link: <http://www.w3.org/2005/10/ubiweb-workshop-cfp.html>

W3C Web Services Addressing Interoperability Event

The W3C Web Services Addressing Working Group held an Interoperability event on 17-18 January in Vancouver, BC, Canada. Participants tested the Web Services Addressing family of W3C specifications. The group has invited interested parties who have implemented Web Services Addressing 1.0: Core, SOAP Binding and/or WSDL Binding.

Link: W3C Web Services Activity: <http://www.w3.org/2002/ws/>

W3C Seminar on Web Services

Paris, 6 March 2006

W3C is organizing a morning of presentations related to the use of Web Services in the industry today. The program of the half day will feature presentations from W3C Members. Web Services are software systems that support interoperable machine-to-machine interactions over a network. They provide an universal glue between different applications within the enterprise, or between different companies. This seminar is funded by the Web Services and Semantics (WS2) project, financed by the European Commission's FP6 IST Programme. Attendance to the seminar is free and open to the public.

Links:

WS2 seminar: <http://www.w3.org/2006/03/ws2-seminar.html>
WS2 project: <http://www.w3.org/2004/WS2/>

Open Access: An Introduction

by Keith G Jeffery

Open Access (OA) means that electronic scholarly articles are available freely at the point of use. The subject has been discussed for over 10 years, but has reached a crescendo of discussion over the last few years with various declarations in favour of OA from groups of researchers or their representatives. The UK House of Commons Science and Technology Committee considered the issue in 2004, reporting in the summer in favour of OA. This indicates the importance of the issue, and led to statements from large research funding bodies such as the Wellcome Trust and the Research Councils UK.

Motivations

Ethics: There is an ethical argument that research funded by the public should be available to the public. Since research is an international activity, this crosses national boundaries.

Research Impact: The Internet provides an opportunity. Modern harvesting techniques and search engines make it possible to discover publications of relevance if they are deposited in an OA repository with a particular metadata standard. If all authors did this then the world of research would be available 'at the fingertips'. There is evidence that articles available in an OA repository have more accesses (readers), citations and therefore impact.

Costs: There is concern over the hindrance to research caused by the cost of journal subscriptions, whether electronic or paper. These costs run well above the rate of inflation with the



result that libraries with restricted budgets (ie all of them!) are no longer providing many journals needed by researchers.

Just reward: There is also concern that in traditional scholarly publishing, most of the work (authoring, reviewing, editing) is done freely by the community and that the publishers make excessive profits from the actual publishing (making available) process. In conventional publishing, the institution subscribes to the publication channel to obtain electronic access or paper copies.

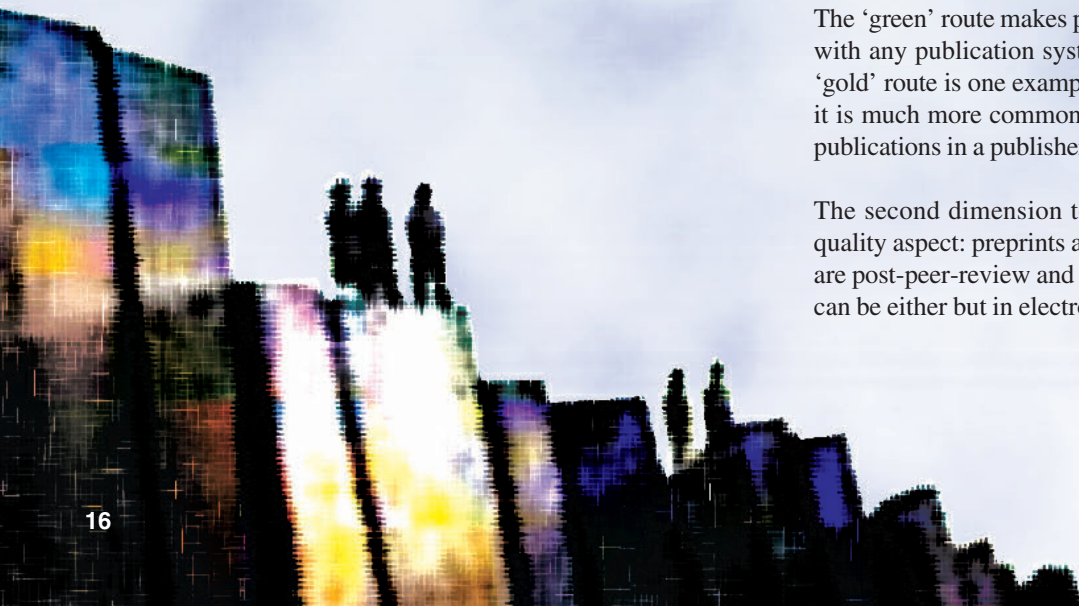
Types of Open Access

At this stage it is important to distinguish several dimensions of the issue: OA can be delivered in two ways:

- 'green': the author can self-archive at the time of submission of the publication (the 'green' route) whether the publication is grey literature (usually internal non-peer-reviewed), a peer-reviewed journal publication, a peer-reviewed conference proceedings paper or a monograph
- 'gold': the author or author institution can pay a fee to the publisher at publication time, the publisher thereafter making the material available 'free' at the point of access (the 'gold' route). The two are not, of course, incompatible and can co-exist.

The 'green' route makes publications available freely in parallel with any publication system but is not, itself, publishing. The 'gold' route is one example of electronic publishing. At present it is much more common to have non-OA electronic access to publications in a publisher's database for a subscription fee.

The second dimension to be distinguished is the timing and quality aspect: preprints are pre-peer-review articles, postprints are post-peer-review and post-publication articles while eprints can be either but in electronic form.



A third dimension is white/grey literature. White literature is peer-reviewed, published articles while grey is preprints or internal 'know-how' material. Of course there are usually many interesting relationships between grey and white articles (see Table).

Barriers to Open Access

Loss of publisher income: The major objection to 'green' self-archiving comes from publishers and learned societies (many of which depend on subscriptions to their publications) who fear that 'green' OA threatens their business viability. To date there is no evidence that 'green' archiving harms the business model of publishing. There is evidence that 'green' archiving increases utilisation, citation and impact of a publication. Whilst the major commercial publishers provide additional value-added services that could offset the impact of OA on current business models, the impact on learned societies may require new business models to be developed.

Copyright: Copyright agreements between authors and publishers may inhibit the 'green' route. However, to date, between 80 and 90% of publication channels (the variability depends on exactly what is counted) allow 'green' author deposit although some insist on an embargo period before the publication is available for OA. In contrast some publishers of journals – of which 'Nature' is the most well-known – do not demand copyright from the author but merely a licence to publish, leaving copyright with the author or their institution.

Green Open Access Repositories

There are two kinds of 'green' OA repository:

- *Thematic:* where authors deposit in a (usually) central repository used by the community and maintained by an appropriate institution and where relevant material on a subject area is collected together. The best known example is arXiv
- *Institutional:* where the authors deposit in a repository maintained by their institution thus collecting together in one place the research output of that institution. This has the advantage of responsibility of ownership and some possible management control/encouragement of deposit.

There are available open source systems for 'green' repositories; the best known being ePrints, DSpace, Fedora and ePubs.

Advantages of Open Access

The major advantage of OA is research impact – the available e-article is likely to have more accesses, citations and impact. However, there are additional advantages:

- *Links:* Electronic availability of a publication (whether 'green' or 'gold') has another advantage; it is possible to crosslink the publication to any research datasets and software used in producing the paper; this improves 'the research process' by permitting other researchers to examine in depth the published work and validate, or contradict, the conclusions.
- *Access:* In the case of non-OA electronic publishing, a researcher has to access separately (with identifier and password provided upon payment of the annual subscription) the databases of publications of each publisher to obtain information. In the case of 'gold' OA publishing a researcher has to access separately the open databases of publications of each publisher to obtain information. In both of these cases the user interface is different from publisher to publisher. In

Green Route	The author can self-archive at the time of submission of the publication whether the publication is grey literature, a peer-reviewed journal publication, a peer-reviewed conference proceedings paper or a monograph
Golden Route	The author or author institution can pay a fee to the publisher at publication time, the publisher thereafter making the material available 'free' at the point of access.
Preprints	Preprints are articles that are pre-peer-review
Postprints	Postprints are articles that are post-peer-review
eprints	eprints can be either preprints or postprints but in electronic form
White Literature	White literature is peer-reviewed, published articles
Grey Literature	Grey literature is preprints or internal 'know-how' material

Dimensions of Open Access publishing.

the case of 'green' open access the OAI-PMH (Open Access Initiative – Protocol for Metadata Harvesting) facility links OA repositories so that all repositories obeying the protocol can be harvested and their contents are available freely.

A Word of Warning

Digitally-created articles rely heavily on both the metadata record and the articles themselves being deposited. International metadata standards and protocols must be applied to repositories so that harvesting across repositories can take place. To ensure that research output material is available for future generations, curation and preservation issues must be addressed.

Speculation: Future

Looking to the future speculatively, it is possible to imagine 'green' OA repositories becoming commonplace and used heavily. At that point, some argue, one could change the business model so that an author deposits in an open access 'green' repository but instead of submitting in parallel to a journal or conference peer-review process, the peer-review is done either by:

- a learned society managing a 'college' of experts and the reviewing process – for a fee paid by the institution of the author or the author;
- allowing annotation by any reader (with digital signature to ensure identification/authentication).

The former peer-review mechanism would maintain learned societies in business, would still cost the institution of the author or the author but would probably be less expensive than publisher subscriptions or 'gold' (author or author institution pays) open access. The latter is much more adventurous and in the spirit of the internet; in a charming way it somehow recaptures the scholarly process of two centuries ago (initial draft, open discussion, revision and publication) in a modern world context. It is this possible future that is feared by commercial publishers.

Acknowledgements

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Publish or Perish — Self-Archive to Flourish: The Green Route to Open Access

by Stevan Harnad

Europe is losing almost 50% of the potential return on its research investment until research funders and institutions mandate that all research findings must be made freely accessible to all would-be users, worldwide.

It is not the number of articles published that reflects the return on Europe's research investment: A piece of research, if it is worth funding and doing at all, must not only be published, but used, applied and built-upon by other researchers, worldwide. This is called 'research impact' and a measure of it is the number of times an article is cited by other articles ('citation impact').

In order to be used and built upon, an article must first be accessed. A published article is accessible only to those researchers who happen to be at institutions that can afford to subscribe to the particular journal in which it was published. There are 24,000 research journals in all today, across all research fields, worldwide, but most institutions can only afford a small fraction of them. In paper days, authors used to supplement this paid access to their articles by mailing free reprints to any would-be users who wrote to request them. The online age has now made it possible for authors to provide limitless free 'eprints' by 'self-archiving' electronic versions of their own final drafts on their own institutional websites for all potential users worldwide who cannot afford the journal version.

The online-age practice of self-archiving has been shown to increase citation impact by a dramatic 50-250%, but so far only 15% of researchers are actually doing it. Yet two recent UK international surveys have found that 95% of authors would self-archive – but only if their research funders or their institutions require them to do so (just as they already require them to 'publish or perish'). The solution is accordingly obvious:

After lengthy deliberations first initiated in 2003 by the UK Parliamentary Select Committee on Science and Technology, Research Councils UK (RCUK) have

proposed to adopt a policy requiring UK researchers to deposit, on their university's website, the final author's draft of any journal article resulting from RCUK-funded research. The purpose of the proposed policy would be to maximise the usage and impact of UK research findings by making them freely accessible on the web ('open access') for any potential users in the UK and worldwide who cannot afford paid access to the published journal version. How would a similar policy maximise the return on Europe's public investment in research?

It is not possible to calculate all the ways in which research generates revenue. A good deal of it is a question of probability and depends on time: Although everyone thinks of an immediate cure for cancer or a cheap, clean source of energy as the kind of result we hope for, most research progresses gradually and indirectly, and the best estimate of the size and direction of its progress is its citation impact, for that reflects the degree of uptake of the research results by other researchers, in their own subsequent research. Citation impact is accordingly rewarded by universities (through salary increases and promotion) as well as by research-funders (through grant funding and renewal); it is also rewarded by libraries (through journal selection and renewal, based on the journal's average citation 'impact factor'). Counting citations is a natural extension of the cruder measure of research impact: counting publications themselves ('publish or perish').

If citations are being counted, it is natural to ask how much they are worth.

For the United States in 1986, Diamond estimated the marginal dollar value of one citation as ranging from \$50-\$1300 (US), depending on field and number of citations. (An increase from 0 to 1 cita-

tion is worth more than an increase from 30 to 31; most articles are in the citation range 0-5.) Taking only the most conservative low-end of this range (\$50), updating by about 170% for inflation from 1986-2005 and converting to Euros, this would yield 73 Euro as the marginal value of a citation to its author today. Self-archiving, as noted, increases citations by 50%+, but, as also noted, only 15% of the articles being published are being self-archived today. Readers can calculate for their own respective countries a conservative estimate (50% citation increase from self-archiving at 73 Euro per citation for 85% of their own country's current annual journal article output) of the total annual loss of revenue to their country's researchers for not having done (or delegated) the few extra keystrokes per article it would have taken to self-archive their final drafts.

But this impact loss translates into a far bigger one for their country's tax-paying public, if we reckon it as the loss of potential returns on their annual research investment: If a country invests R billion Euros in its research, this translates into the loss of $50\% \times 85\% = 42.5\%$ or close to R/2 billion Euros' worth of potential citation impact simply for failing to self-archive it all. It is as if someone bought R billion Euros worth of batteries and lost 42.5% of their potential usage simply for failing to refrigerate them all before use. And that is without even considering the wider loss in revenue from the loss of potential practical usage and applications of each nation's research findings in Europe and worldwide, nor the still more general loss to the progress of human inquiry.

The solution is obvious, and it is the one the RCUK is proposing: to extend research's existing universal 'publish or perish' requirement to 'publish and also self-archive your final draft on your

institutional website'. Over 90% of journals are already 'green' on author self-archiving; two international author surveys report that over 90% of authors will comply; and the actual experience of the five institutions that have so far already adopted such a requirement (CERN, University of Southampton ECS, Queensland University of Technology, University of Minho, University of Zurich) tends to bear this out.

The time for Europe to close its own 50%-250% research impact gap is already well overdue. All of Europe should immediately follow the UK model, adopting the web-age extension of "publish or perish" policy to: "publish and self-archive on the web." This tiny and very natural evolutionary step will not only be of enormous benefit to Europe's researchers, its institutions, its funders, and its funders' funders (ie, the tax-payers), but it will also be to the collective advantage of global research progress and productivity itself, and the object of emulation worldwide.

Links:

- Ulrich's periodical directory: <http://www.ulrichsweb.com/>
- Statistics provided by the Association of Research Libraries: <http://fisher.lib.virginia.edu/arl/>
- Self-Archiving FAQ: <http://www.eprints.org/openaccess/self-faq/>
- Institutional Archives Registry: <http://archives.eprints.org/eprints.php?action=browse>
- Comparing the Impact of Open Access vs. Non-OA Articles in the Same Journals, D-Lib Magazine, June 2004: <http://eprints.ecs.soton.ac.uk/10207/01/06harnad.html>
- Swan, A. (2005) Open access self-archiving: An Introduction. Technical Report, JISC, HEFCE: <http://eprints.ecs.soton.ac.uk/11006/>
- Recommendations for UK Open Access Provision Policy: <http://www.ecs.soton.ac.uk/%7Eharnad/Temp/UKSTC.htm>
- UK Research Councils' Position on Access to Research Outputs: <http://www.rcuk.ac.uk/press/20050628openaccess.asp>
- Effect of open access on citation impact: a bibliography of studies: <http://opcit.eprints.org/oacitation-biblio.html>
- Carr, L. and Harnad, S. (2005) Keystroke Economy: A Study of the Time and Effort Involved in Self-Archiving: <http://eprints.ecs.soton.ac.uk/10688/>
- Journal Policies - Summary Statistics So Far: <http://romeo.eprints.org/stats.php>

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The Golden Route to Open Access

by Jan Velterop

Publishing research results is part and parcel of doing research. Without publishing it, one can just as well not do the research. Publishing is not just an option for a serious scientist, but more or less compulsory, albeit to a degree a 'social compulsion' - it is "the right thing to do". Often enough, though, it is an inescapable requirement for those who want to make a career in science. Without having a good number of publications to your name, you will find it difficult to make promotion, qualify for tenure, obtain funding for further projects, and get the acknowledgement and recognition most scientists crave. The slogan 'publish or perish' will sound familiar.

Given this, it is quite remarkable that doing research and subsequently publishing the results have been regarded as mostly separate processes, taking place in separate worlds. And it is perhaps even more remarkable that to an overwhelming degree the whole process of publishing has hitherto been financed by contributions (vicariously, via libraries) from readers. I say 'to an overwhelming degree' because it is not quite so that the process is entirely financed by readers, as there is, in some disciplines, a small contribution from authors in the form of page charges. This contribution, how-

ever, defrays a very small proportion of the overall cost of publishing.

'Publishing' is quite a loose and ill-delimited term which in the context of science and scholarship comprises a number of 'ations': registration, certification, dissemination, information, preservation, and compensation. 'Registration' means recording that the research has taken place, by whom, when, where, and the like, and ensures proper acknowledgement and citation. 'Certification' means that it has passed the filter of peer-review and thus conforms to the standards of dili-

gence of the discipline in question. 'Dissemination' speaks for itself and is the element most directly influenced — improved — by open access. 'Information' refers to the actual transfer of data or knowledge contained in a scientific article; from researcher to researcher, but also from researcher to student and on occasion directly to the general public. 'Preservation' means proper archiving and ensuring that the material will be accessible and usable in the future, which is considered quite a challenge for electronic material. And finally 'compensation', which denotes the fact that as a

researcher, having published as expected by one's institution and funding body, one can avoid perishing as a scientist (though actually thriving requires a bit more, such as citations to one's articles).

If one looks at these 'ations', it is striking that most are of much more importance to the authors of the material than to prospective readers. Whether a given article is published or not will hardly ever register with readers. There are even voices who say that what readers need most are articles that are rarely ever published: negative results. For the author, however, publishing research results is really part of completing the research process and of utmost importance, hence the adage 'publish or perish' and not 'read or rot'.

As said, open access to research articles does potentially enhance many of the things that are important to authors: dissemination, and with it visibility, the chance of being cited, information and the chance of influencing ideas, and even preservation because wide distribution of the material provides some 'safety in numbers'.

However, open access means that the traditional way of financing publishing

needs to be reconsidered. After all, when articles are openly and freely available, the incentive for the reader (vicariously, the library) to pay for subscriptions or licences is materially diminished. Only financing the system by contributions from authors (vicariously, from institutions or funding bodies), who have a very strong incentive to have their articles published, makes open access publishing economically feasible and robust. This has come to be known as the Golden Route to open access. It makes sense if one considers that in the end it is neither readers nor authors who pay for the system anyway, but academic institutions and funders, either via subscriptions — having no open access — or via article publishing charges, having open access and all its benefits.

Unfortunately, making the transition is fiendishly difficult. Most publishers have therefore, hitherto, stayed away from the Gold Route to open access, and a few, very few, new ones have fully embraced the model and are trying to build their entire business on it. None of those have so far been able to make it work economically, perhaps demonstrating the formidable difficulties and challenges a transition to open access presents. The

goal of open access is worth overcoming those challenges, though. In order to help make the transition, at Springer we have decided to leave the choice to authors (and their institutions and funders). They can, once their article has been accepted for publication after peer review, opt to have it published in the traditional way, and disseminated via subscriptions, or opt to have it published with immediate and full open access. The scheme called Springer Open Choice, applies to all the 1300 or so journals that the company publishes, and it is hoped that it provides an opportunity to make a smooth transition from traditional publishing to Gold Open Access publishing, at the pace that the scientific community is comfortable with, and that it will be followed by other publishers. A few of those other established publishers have recently instituted a similar choice model for a small number of their journals, perhaps indicating that the idea may be catching on.

Link:
<http://www.springer.com/openchoice>

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ERCIM Statement on Open Access

ERCIM researchers have an interest in Open Access both as producers and consumers of research publications, and as developers of technology to enable and sustain open access.

Recognising the inability of research libraries to meet the costs of sustaining their collections, and participating actively in the development of appropriate technology, ERCIM has followed with interest the developments in Open Access from the Budapest Declaration through the Bethesda Declaration to the Berlin Declaration and events since. ERCIM member organisations have been involved in dialogue with national libraries, research funding agencies, commercial publishers, learned societies and government departments. ERCIM supports the following principles:

- research that is funded by the public via government agencies or charities should be available freely, electronically at the point of use
- other research should be made equally available subject only to confidentiality required by commercial, military, security or personal medical constraints
- quality assurance of research publications must be continued through rigorous peer review
- associated with research publications, research datasets and software should be equally openly available

- the provision of open access should be made as cost-effective as possible
 - the provision of open access carries also the responsibility for curation of the digital material including cataloguing, archiving, reproducing, safekeeping and media migration.
- ERCIM has for many years made available digitally its publications and other materials. ERCIM pioneered a pilot project demonstrating homogeneous access to heterogeneous technical reports. ERCIM has many years experience in the technology through the DELOS projects and Network of Excellence (<http://www.delos.info>), and is at the leading edge integrating appropriate open access technology with GRIDS via the DILIGENT project (<http://www.diligentproject.org>). Individual ERCIM organisations have researched many aspects of the technology required for open access.

It is now agreed that the member organisations of ERCIM which do not already have an open access policy will adopt these principles and implement them.

Managing Licenses in an Open Access Community

by Renato Iannella

A new project from National ICT Australia (NICTA) and Queensland University of Technology (QUT), called 'Open Access to Knowledge (OAK), aims to address the emerging needs of the open access community in licensing content.

In particular, OAK will be developing a set of legal requirements and generic licenses that can be used to negotiate and transact (ie share) digital content in an online environment. Technically, the OAK project will develop robust Rights Expression Language (REL) models and Profiles of the machine-readable Open Digital Rights Language (ODRL). OAK will implement technological mechanisms to improve open access and management through the application of these license protocols and services to existing digital repositories.

The Creative Commons (CC) has provided worldwide interest in simple licensing of content for the open access communities. The range of CC license templates have addressed the legal and community awareness needs for content licensing. The mapping of the standard licenses to other countries legal regimes has ensured the international impact of CC. However, there are still some legal and technical issues that remain a challenge and these will be investigated in the OAK Project.

Some of the legal issues are compounded by the lack of technical solutions. For example, the need to keep the licenses attached or associated with the content at all times is difficult to implement generically across all media types. And the failure of this at any point in the distribution of the content will breach the license conditions, and may result in licensed content being re-distributed without proper knowledge of the license conditions.

The CC REL is a compact rendering of the semantics of the legal licenses. In most cases the REL captures the broad license conditions, such as the right to produce derivatives, or prohibits commercial usage. However, in some cases, the REL does not capture these seman-

tics. For example, in the CC Sampling licenses the legal code is clear that you cannot use the work for advertising but there is no corresponding constraint semantics in the CC REL.

One of the major technical hurdles for the CC licenses is the lack of extensibility of its machine-readable REL. For example, a recent report from the UK Common Information Environment (CIE) on the use of Creative Commons in the public and education sectors raised a number of areas where the CC licenses lacked support, including:

- geographic restrictions
- sector restrictions
- third party material (including limited duration)
- no endorsement clause.

In general there are no mechanisms for CC licenses to be tailored to specific needs of some communities, which could impact on the uptake and broader use of CC style licenses. The ODRL Initiative and the Creative Commons have jointly developed a Profile of the CC REL semantics that have been mapped into the more expressive ODRL REL. This Profile does enable greater extensibility and provides semantic structures to extend the reach of the template licenses.

The OAK Project will build on the emerging new intellectual property rights model being developed for ODRL Version 2.0 that provides new features (such as Duties and Prohibitions) and supports a wider range of License types. Another objective of this project will be to investigate software solutions to support the ODRL Profiles developed for open content repositories. These will include protocols to support negotiation of licenses between parties.

Most license management systems today are focussed on the distribution of commercial and consumer-oriented content, such as music to mobile phones. The motive of the OAK project is to investigate the legal, semantic, and technical issues of licensing content in the creative industry communities. That is, communities that support a high level of sharing (eg research, science, and education) without a strict requirement for enforcement of content usage, but still requiring intellectual property rights to be maintained, honored, and managed. This project will be of immediate benefit to these communities in that it will increase the ability to access a vast array of content and research material. In an environment where access to knowledge is increasingly important to quality of life and career advancement this will provide an important resource to the broader community of knowledge consumers.

Links:

ODRL: <http://odrl.net>

CC: <http://creativecommons.org>

CIE: <http://www.common-info.org.uk/>

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W3C at the Forefront of Open Access

by Rigo Wenning

The Web can be seen as one of the preconditions of today's discussion about Open Access. The World Wide Web Consortium (W3C), including its Members, is very conscious about this role of the Web. To give an example, the W3C, from its earliest days, has used Web technologies to provide full access to the W3C Recommendations and Working Drafts and much other information on the W3C's Web site.

All W3C Recommendations and normative documents are published under the very liberal W3C document license. This license allows people to re-use the document content in all kinds of innovative ways, on condition that the initial Recommendation and its attribution to W3C are not altered. The limitation related to document changes is due to the normative character of the W3C Recommendations, since they represent a consensus of the community. The prohibition to change and create derivatives of the W3C Recommendation protects this consensus. W3C additionally has a liberal software license that allows the W3C open source code to be altered, contributed to, and incorporated in either open-source or commercial software.

Patent Policy

In the early years of W3C's work on Web standards, innovation arose out of a combination of community-wide collaboration on open standards and fierce competition in implementation of those standards. Patents were not initially identified as a barrier to innovation or interoperability because no one was aware of any patent claims asserted to block standards-based interoperability. However, as the Web became more commercially prominent and the number of software and business process patents increased, some patent holders sought to require license payments as a condition of implementing Web standards. In some cases, these patent holders had also participated in the development of those standards. Based on its experience, the W3C community came to the conclusion that it is essential to have a clear patent policy governing standards development. The policy W3C has adopted was designed to assure the continuation of the fundamental dynamics of innovation and interoperability that made the Web successful.

After three years of lengthy and controversial discussions, in 2004 the W3C adopted its Patent Policy, a landmark innovation in the area of standardization. While most Specification Developing Organizations (SDO's) have adopted a RAND-scheme (reasonable and non-discriminatory terms), W3C was the first SDO to adopt a regime of royalty free and non-discriminatory licensing terms for every patent essential to the implementation of a W3C Recommendation. This was a major step to help W3C Recommendations to get the most widespread use and recognition. While the innovative Patent Policy created several issues in business procedures for W3C as well as for its Members, today we are already seeing other SDOs copy the model and numerous discussions sparking up elsewhere.

Accountability to the Public

The W3C is also conscious that not every individual can contribute by becoming a W3C Member. Therefore the W3C has developed a very open process to accommodate views from the public at large. Those contributions and comments have to be taken into account by W3C Working Groups. The Working Groups are expected to respond to comments, and document decisions about whether they accept the suggestion or not. The simplicity of the Working Groups' email-based feedback approach is contributing greatly to the reach of W3C technologies. Those comments and the responses are publicly archived for accountability and for information. Furthermore, today W3C technologies can be used in all kinds of languages, written vertically or from right to left, such as in Chinese or Arabic. This aim to include every community makes the scale of the Web truly global.

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Links

Background Documents on OA

- Self-archiving FAQ:
<http://www.eprints.org/self-faq/>
- Bibliography of OA Advantage:
<http://opcit.eprints.org/oacitation-biblio.html>
- American Scientist Open Access Forum:
<http://amsci-forum.amsci.org/archives/American-Scientist-Open-Access-Forum.html>

Policy

- Budapest:
<http://www.soros.org/openaccess/read.shtml>
- Bethesda:
<http://www.earlham.edu/~peters/fos/bethesda.htm>
- Berlin Declaration:
<http://www.zim.mpg.de/openaccess-berlin/signatories.html>
- OECD:
http://www.oecd.org/document/15/0,2340,en_2649_201185_25998799_1_1_1_1,00.html
- UK House of Commons Science and Technology Select Committee:
<http://www.publications.parliament.uk/pa/cm200304/cmselect/cmsctech/399/3990>
- RCUK:
<http://www.rcuk.ac.uk/access/statement.pdf>

Policies, Registries and Directories

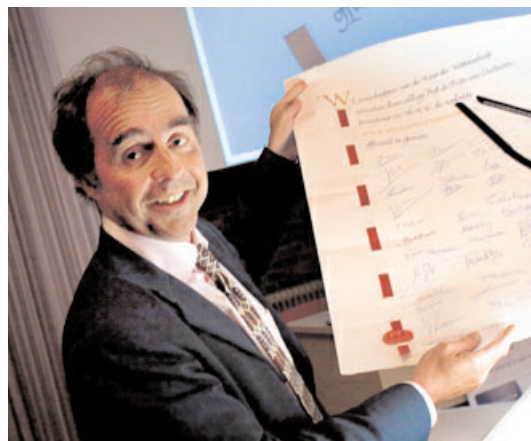
- Overview:
<http://www.openarchives.org>
- Institutional Archives Registry:
<http://archives.eprints.org/eprints.php>
- Institutional Self-Archiving Policy Registry
<http://www.eprints.org/signup/fulllist.php>
- Journal Self-Archiving Policy Directory <http://romeo.eprints.org/>
- 'Gold' open-access publication channels: <http://www.doaj.org/>
- Self-archive repositories:
<http://www.eprints.org/self-faq/>
<http://archives.eprints.org/>
<http://openaccess.eprints.org/>

Cream of Science

by Wouter Mettrop

In the Netherlands, a national project has started that aims to make available the scientific output of all Dutch scientific organizations according to the Open Archives Initiative protocol.

On 10th May 2005 the president of the Netherlands Academy of Arts and Sciences (KNAW) Prof. dr. Frits van Oostrom launched the website www.creamofscience.org. It was the result of months of very hard work for the project 'Keur der Wetenschap' (Cream of Science) at all Dutch univer-



Prof. Dr. Frits van Oostrom launches Cream of Science (Photo courtesy of Theo Koeten Photography).

sity libraries, KNAW and also at CWI. They were each asked to put the complete scientific output of about ten active scientists in a repository. This project is part of the national project DARE (Digital Academic Repositories). DARE aims at stimulating so called Institutional Repositories (IR) in the Netherlands. These IRs aim to make available the scientific output of all Dutch scientific organizations both digitally and according to the international OAI - Open Archives Initiative - protocol.

Copyright was an important issue for many participating libraries and authors. Is it proper to publicly present publications without the author's permission? DARE investigated this matter and it turned out that all material dated before 1998 can be admitted to repositories without legal restrictions. Research also

showed that authors often do not know that signing the author-publisher agreement means that they give away their copyright to a commercial publisher. DARE partners dealt differently with publication dated from 1998. Some only recorded the metadata from publications of that period whereas others recorded all publications, often at request of the scientists.

On behalf of NWO (Netherlands Organisation for Scientific Research) the CWI Library takes part in DARE. It will also host the output of the other NWO institutes, although each institute will be responsible for their own input. The CWI-IR can be found through the Keur website or at www.darenet.nl, where also some CWI reports of the past years can be found. In the near future an interface will be installed on CWI-IR, which can be searched separately. Gradually the publications of all past and present CWI researchers will be put in the repository.

CWI emphasizes that participation in Keur der Wetenschap is very useful as a start for an Institutional Repository. Eventually the importance of an IR according to the OAI protocol is to be found in the possibility of subject-based 'harvesting' by international service providers.

Link:

<http://www.creamofscience.org>

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JISC surveys of international author Open Access

- Swan, A. and Brown, S. (2004) ISC/OSI JOURNAL AUTHORS SURVEY Report. Technical Report, JISC, HEFCE: <http://eprints.ecs.soton.ac.uk/11002/>
- Swan, A. and Brown, S. (2005), Open access self-archiving: An author study. Technical Report, External Collaborators, JISC, HEFCE: <http://eprints.ecs.soton.ac.uk/10999/>
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Emergent Computing

Introduction to the Special Theme

by Heather J. Ruskin and Ray Walshe

Emergent Computing has become more topical in the last few years and has recently been categorised as a research field in its own right. The history of the field lies primarily in Artificial Intelligence, Numerical Methods and Complexity Theory all of which have contributed in no small part to Emergent Computing. Emergent Computing is sometimes described as 'highly complex processes arising from the cooperation of many simple processes', ie high-level behaviour resulting from low-level interaction of simpler building blocks. One example of emergent behaviour that has been studied over recent years is that of 'flocking'. In a 'flock of birds', the flock is a dynamic entity consisting of hundreds (or thousands) of individuals. The flock constantly changes shape and direction but maintains overall cohesion. Using cellular automata and treating each bird in the flock as an autonomous agent, with simple local rules controlling agent behaviour relative to closest neighbouring birds, a system can be constructed where the overall behaviour of the collective agents reflects the behaviour of the real flock.

The Emergent Computing paradigm both explores and relies upon biologically and socially inspired systems, in which complex behaviour at the global level emerges in a non-linear manner from large numbers of low-level component interactions. Building software systems, using this component methodology, offers many advantages for solving complex problems, since the algorithmic complexity is achieved through software that is simple and flexible compared to conventional software development techniques

Building systems, with behaviour more than the sum of its parts, attracts methodologies and techniques from a number of disciplines, so we include as a broader definition of the topic, the mathematical and computational techniques that underpin the area of Emergent Computing. These include examples such as classifier systems, neural networks, biological immune systems, autocatalytic networks, adaptive game theory, chaos theory, general nonlinear systems and artificial life.

Recent increased interest in these topics is illustrated by the many international conferences

and workshops aimed at Emergent Computing, Emergent Properties, Complexity and Co-Evolution, to name but a few. The European Commission has also recently published the fifth call for proposals under the 'information society technologies' (IST) priority of the Sixth Framework Programme (FP6), which falls under the seminal programme of 'integrating and strengthening the European Research Area'. Significantly, a specific targeted research initiative, included in FP6, is the research heading 'Simulating Emergent Properties in Complex Systems'.

Emergent Computing is influenced by and borrows heavily from other disciplines and one of the most prolific symbioses has been that with Biology. Systems Biology has provided many bio-inspired approaches, (Biomimetic models and methods), giving rise to emergent properties. Neural networks, (from the biological 'neuron' operation), which form the basis of many clustering, classification and learning systems, provide one of the earliest examples. Emergence of conditions, favourable to viral invasion and disease spread, has been modelled using cellular automata and autonomous agent methodologies. The behaviour patterns of swarming bees, flocking birds and schools of fish, have generated so-called swarm technologies, used in complex dynamic systems problems such as scheduling, optimisation and space exploration. Similarly, a portfolio of mathematical and numerical methods, statistical and probabilistic reasoning, have found applications in learning systems for adaptation and prediction, linguistics, intelligence and control.

As the field of emergent computing progresses and computational power allows us to look more closely at the individual components, to manipulate them more efficiently, and to combine and compare readily existing techniques with new and hybrid methodologies, evolutionary complexity seems almost within our grasp. As size and sophistication increase of what can be modelled, useful insight may be gained on systems and applications, with scales ranging from the sub-cellular to the social and beyond.

This issue aims to highlight some of the areas and techniques of current interest internatio-



nally in Emergent Computing research, through both special theme articles submitted and invited articles from key researchers.

The invited articles introduce topics such as:

- unmanned space exploration using intelligent swarm technologies
- co-evolution of emergent properties in collective systems (collective intelligence)
- evolution of computer programs by artificial selection, using genetic programming, to obtain human-competitive game-playing strategies

The 21 special theme articles in this issue highlight current research trends, not only within the ERCIM community, but more widely across Europe. Included are topics, such as:

- evolving higher order intelligence and evolving classifier systems
- particle swarm optimisation in microwave backscattering data and metaheuristics in which a decentralized design leads to emergent phenomena
- fuzzy coalitions in game playing
- self-organised and self-optimisation in dynamic networks and chemical programming
- predictive modelling in financial networks and statistical modelling frameworks
- evolvable hardware using a multi-cellular organism approach
- emergent development in the walking behaviour of a robot
- agent based modelling of viral infection and network emergence in the immune system
- collaborative online development of modular intelligent agents and emergent intelligence in competitive multi-agent systems.

Link:

<http://bioinformatics.computing.dcu.ie>

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Swarm-Based Space Exploration

by Michael G. Hinchey, Roy Sterritt, Christopher A. Rouff, James L. Rash and Walt Truskowski

Future space exploration missions will exploit intelligent swarm technologies, enabling spacecraft to go where manned missions and traditional spacecraft simply cannot.

Planned NASA missions will exploit new paradigms for space exploration, heavily focused on the (still) emerging technologies of autonomous and autonomic systems. Traditional missions, reliant on one large spacecraft, are being complemented by missions that involve several smaller spacecraft, operating in collaboration, analogous to swarms in nature.

This offers several advantages: the ability to send spacecraft to explore regions of space where traditional craft simply would be impractical, greater redundancy (and, consequently, greater protection of assets), and reduced costs and risk, to name but a few.

ANTS: A Concept Mission

ANTS (Autonomous Nano Technology Swarm) is a concept NASA mission. In one of its sub-missions, Prospecting Asteroid Mission (PAM), a transport ship, launched from Earth, will travel to a point in space where gravitational forces on small objects (such as pico-class spacecraft) are all but negligible. From this point, termed a Lagrangian, 1000 spacecraft, which will have been assembled en route from Earth, will be launched into the asteroid belt. It is expected that as much as 60 to 70 percent of them will be lost during the mission, primarily because of collisions with each other or with an asteroid during exploration operations, since, having only solar sails to provide thrust, their ability to maneuver will be severely limited. Because of their small size, each spacecraft will carry just one specialized instrument for collecting a specific type of data from asteroids in the belt.

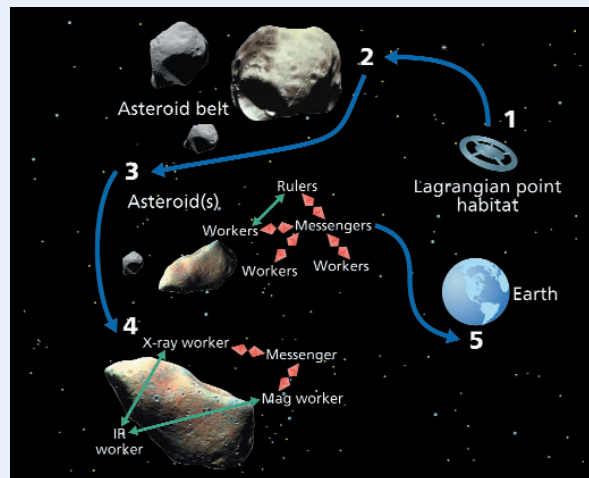
Approximately 80 percent of the spacecraft will be workers that will carry the specialized instruments (eg, a magnetometer or an x-ray, gamma-ray, visible/IR, or neutral mass spectrometer)

and will obtain specific types of data. Some will be coordinators (called leaders) that have rules that decide the types of asteroids and data the mission is interested in and that will coordinate the efforts of the workers. The third type of spacecraft are messengers that will coordinate communication between the rulers and workers, and communications with the Earth ground station.

The swarm will form sub-swarms under the control of a ruler, which contains models of the types of science that it

A Complex Problem

New approaches to exploration missions such as ANTS augur great potential, but simultaneously pose many challenges. The missions will be unmanned and necessarily highly autonomous. They will also exhibit the properties of autonomic systems of being self-protecting, self-healing, self-configuring, and self-optimizing in order to assist in the survivability of the mission. Many of these missions will be sent to parts of the solar system where manned missions are simply not possible, and to where the round-



The operational ANTS mission concept.

wants to perform. The ruler will coordinate workers, each of which uses its individual instrument to collect data on specific asteroids and feed this information back to the ruler, who will determine which asteroids are worth examining further. If the data matches the profile of a type of asteroid that is of interest, an imaging spacecraft will be sent to the asteroid to ascertain the exact location and to create a rough model to be used by other spacecraft for maneuvering around the asteroid. Other teams of spacecraft will then coordinate to finish mapping the asteroid to form a complete model.

trip delay for communications to spacecraft exceeds 40 minutes, meaning that the decisions on responses to problems and undesirable situations must be made in situ rather than from ground control on Earth.

NASA Goddard Space Flight Center has been collaborating with University of Ulster and Science Applications International Corp. (SAIC) on developing techniques and new self-paradigms, which may be applicable to future swarm-based missions. In addition, the degree of autonomy that such missions will possess would require a prohibitive amount of testing in order to accomplish

system verification. Furthermore, learning and adaptation with the goal of continual improvements in performance will mean that emergent behavior patterns simply cannot be fully predicted through the use of traditional system development methods.

The Formal Approaches to Swarm Technology (FAST) project aims at devising a formal approach to the development and verification of complex swarm-based systems, using ANTS as a baseline for comparing approaches.

An effective formal method for use in the ANTS mission must be able to pre-

dict the emergent behavior of 1000 agents operating as a swarm, as well as the behavior of the individual agents. Crucial to the success of the mission will be autonomic properties and the ability to modify operations autonomously to reflect the changing nature of the mission. For this, the formal specification will need to be able to track the goals of the mission as they change and to modify the model of the universe as new data comes in. The formal specification will also need to allow for specification of the decision-making process to aid in the decision of which instruments will be needed, at what location, with what goals, etc.

The project is currently working on integrating existing formal techniques and on building tools to support the integrated method.

Links:

ANTS website: <http://ants.gsfc.nasa.gov>

NASA Software Engineering Laboratory:
<http://sel.gsfc.nasa.gov>

UU Autonomic Systems:

<http://www.infj.ulst.ac.uk/~autonomic>

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Collective Intelligence and Evolution

by Akira Namatame

The mission of collective evolution is to harness the systems of selfish agents to secure a sustainable relationship, so that desirable properties can emerge as 'collective intelligence'.

Why do colonies of ants work collectively, and how do they do it so effectively? One key to answering this question is to look at interactions among ants. For the last decade, attempts have been made to develop some general understanding, which has produced the theory of collective systems, that is, systems consisting of a large collection of agents. It is common to refer to the desirable emergent properties of collective systems as 'collective intelligence'. Interactions are able to produce collective intelligence at the macroscopic level that is simply not present when the components are considered individually.

The concept of collective intelligence observed in social insects can be extended to humans. In his book, *The Wisdom Of Crowds*, Surowiecki explores a simple idea that has profound implications: a large collection of people are smarter than an elite few at solving problems, fostering innovation, coming to wise decisions, and predicting the future. His counterintuitive notion, rather than crowd psychology as traditionally understood, provides us with new insights for understanding

how our social and economic activities should be organized.

On the other hand, the fact that selfish behaviour may not achieve full efficiency is also well known in the literature. It is important to investigate the loss of collective welfare due to selfish and uncoordinated behavior. Recent research efforts have focused on quantifying this loss for specific environments, and the resulting degree of efficiency loss is known as 'the price of anarchy'. Investigations into the price anarchy have provided some measures for designing collective systems with robustness against selfish behaviour. Collective systems are based on an analogous assumption that individuals are selfish optimizers, and we need methodologies so that the selfish behaviour of individuals need not degrade the system performance. Of particular interest is the issue of how social interactions should be restructured so that agents are free to choose their own actions, while avoiding outcomes that none would choose.

Darwinian dynamics based on mutation and selection form the core of models for

evolution in nature. Evolution through natural selection is often understood to imply improvement and progress. If multiple populations of species are adapting each other, the result is a co-evolutionary process. However, the problem to contend with in Darwinian co-evolution is the possibility of an escalating arms race with no end. Competing species may continually adapt to each other in more and more specialized ways, never stabilizing at a desirable outcome.

The Rock-Scissors-Paper (RSP) game is a typical form of representing the triangular relationship. This simple game has been used to explain the importance of biodiversity. We generalize a basic rock-scissors-paper relationship to a non-zero-sum game with the payoff matrix shown in Table 1. In this triangular situation, diversity resulting from proper dispersal by achieving Nash equilibrium is not efficient, and the agents may benefit from achieving a better relationship.

In particular, we have examined the system of interactive evolving agents in the context of repeated RSP games, by con-

Opponent Choice \ Own choice	$S_1(0)$ (Rock)	$S_2(1)$ (Scissors)	$S_3(2)$ (Paper)
$S_1(0)$ (Rock)	1	0	λ
$S_2(1)$ (Scissors)	λ	1	0
$S_3(2)$ (Paper)	0	λ	1

Table 1: The generalized rock-scissors-paper game ($\lambda \geq 2$).

Considering a population of agents located on a lattice network of 20x20. They repeatedly play the generalized RSP game with their nearest eight neighbours based on the coupling rules, which are updated by the crossover operator. 400 different rules, one for each agent, are aggregated at the beginning into a few rules with many commonalities. The game between two agents with the learned coupling rule becomes a kind of stochastic process. The transitions of the outcome are represented as the phase diagram in Figure 1, and they converge into the limit cycle, visiting the Pareto-

optimal outcomes: (0,1) (1,2) (2,0) (1,0) (2,1) (0,2). Therefore each agent learns to behave as follows: win three times and then lose three times. In this way, the agents succeed in collectively evolving a robust learning procedure that leads to near-optimal behaviour based on the principle of give and take.

The framework of collective evolution is distinguished from co-evolution in three aspects. First, there is the coupling rule: a deterministic process that links past outcomes with future behaviour. The second aspect, which is distinguished from individual learning, is that agents may wish to optimize the outcome of the joint actions. The third aspect is to describe how a coupling rule should be improved, using the criterion of performance to evaluate the rule.

In biology, the gene is the unit of selection. However, the collective evolutionary process is expected to compel agents towards ever more refined adaptation, resulting in sophisticated behavioural rules. Cultural interpretations of collective evolution assume that successful behavioural rules are spread by imitation

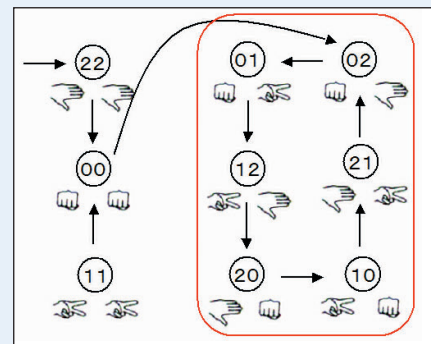


Figure 1: The state diagram of the strategy choices between two agents.

or learning by the agents. This approach to collective evolution is very much at the forefront of the design of desired collectives in terms of efficiency, equity, and sustainability. Further work will need to examine how collective evolution across the complex socio-economical networks leads to emergent effects at higher levels.

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Evolving Game-Playing Strategies with Genetic Programming

by Moshe Sipper

We have recently used genetic programming, wherein computer programs evolve by artificial selection, to obtain human-competitive game-playing strategies for three games: chess, backgammon, and Robocode.

The idea of applying the biological principle of natural evolution to artificial systems, introduced over four decades ago, has seen impressive growth in the past few years. Evolutionary algorithms have been successfully applied to numerous problems from different domains, including optimization, automatic programming, circuit design, machine learning, economics, immune systems, ecology, and population genetics, to mention but a few. Our group focuses on the evolutionary methodology known as genetic programming.

In genetic programming we evolve a population of computer programs,

whose basic building blocks are designed for the problem at hand. For example, when we evolved backgammon-playing programs the list of elements from which programs could be constructed included:

- Player-Exposed(n): Test whether the player has exactly one checker at board location n
- Player-Blocked(n): Test whether the player has two or more checkers at location n
- Enemy-Exposed(n): Test whether the enemy has exactly one checker at board location n
- Sub(F, F) : Subtract two real numbers.

The full list (for backgammon) comprises over 20 such programmatic elements.

The main mechanism behind genetic programming is that of a generic evolutionary algorithm (which, in turn, is inspired by nature), namely, the repeated cycling through four operations applied to the entire population: evaluate, select, crossover, and mutate. Start with an initial population of randomly generated programs composed of the program elements for the problem at hand (eg, backgammon); this random population is known as generation zero. Each individual is then evaluated in the domain environment and assigned a fitness value rep-

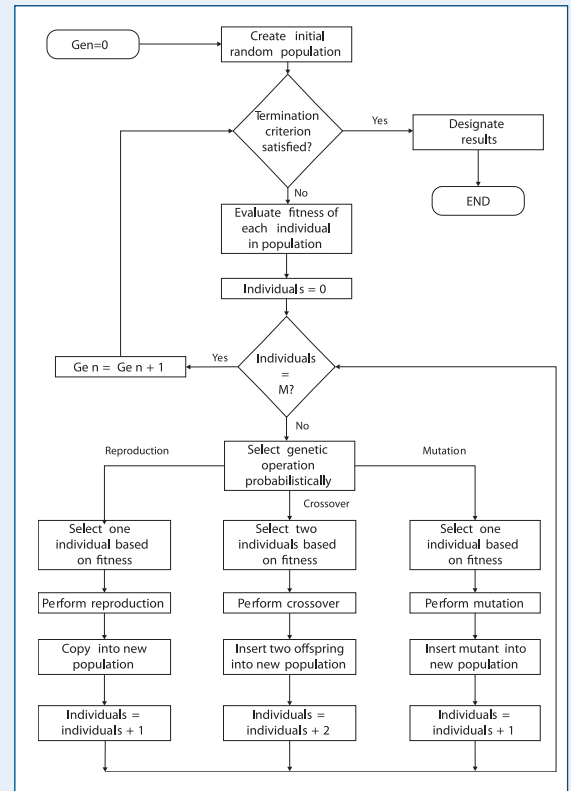
resenting how well the individual solves the problem at hand. In the backgammon example fitness can be assigned by having each individual play against some external (perhaps commercial) program that acts as a teacher, or by having the individuals play against each other, the latter referred to as coevolution.

Being randomly generated, the first-generation individuals usually exhibit poor performance. However, some individuals are better than others, ie, (as in nature) variability exists, and through the mechanism of natural (or, in our case, artificial) selection, these have a higher probability of being selected to parent the next generation. Once individuals have been probabilistically selected in accordance with fitness, two genetically inspired operators are applied: crossover, which takes two individual programs, ‘cuts’ each in two, and then combines the four resulting pieces to create two new viable offspring; and mutation, which takes one program and mutates it, ie, changes it in some random manner that results in a different (legal) program. Thus we have gone through one evaluate-select-crossover-mutate cycle, known as a generation. Repeating this procedure, cycling through several generations, may ultimately lead to good solutions to the given problem, in our case an artificial player able to hold its own against human or machine players.

Other than backgammon we tested our evolutionary approach on two other games — chess, and Robocode — obtaining excellent results:

- *Backgammon*: We evolved full-fledged players for the non-doubling-cube version of the game. Pitted against Pubeval, a standard benchmark program, our top programs won 62% of the matches, 10% higher than top

Figure 2:
Generic programming flowchart. M is the population size and Gen is the generation counter. The termination criterion can be the completion of a fixed number of generations or the discovery of a good-enough individual.



previous machine players—quite a significant improvement.

- *Chess (endgames)*: We evolved players able to play several types of endgames. While endgames typically contain but a few pieces, the problem of evaluation is still hard, as the pieces are usually free to move all over the board, resulting in complex game trees—both deep and with high branching factors. We pitted our evolved GP-EndChess players against two very strong programs: MASTER (which we wrote based on consultation with high-ranking chess players) and CRAFTY—a world-class chess program, which finished second in the 2004 World Computer Speed Chess Championship. GP-EndChess was able to draw most of the time and even

win now and again, ie, the evolved program definitely holds its own.

- *Robocode*: A simulation-based game in which robotic tanks fight to destruction in a closed arena. The programmers implement their robots in the Java programming language and may submit them to a central web site where online tournaments regularly take place. GP-Robocode’s best score was first place of 28 in the international league, with all other 27 players having been written by humans.

These results recently earned us a Bronze Medal in the 2005 Human-Competitive Awards in Genetic and Evolutionary Computation competition, where the objective was to have evolution produce results competitive with humans.

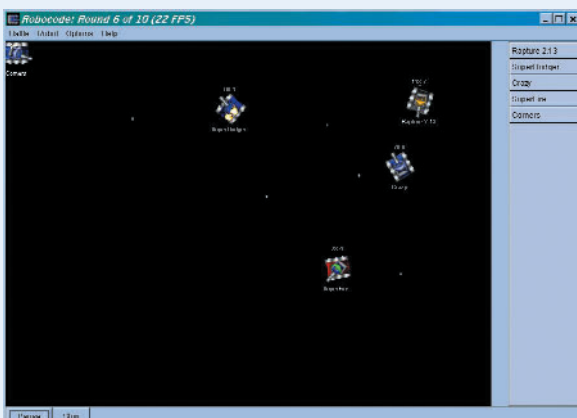


Figure 1:
Robocode interface.

Links:

Author’s website:

<http://www.moshesipper.com/>

Human-competitive awards:

<http://www.human-competitive.org/>

GP-Robocode wins first place:

<http://robocode.yajags.com/20050625/haiku-1v1.html>

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Collaborative Online Development of Modular Intelligent Agents

by Ciarán O’Leary, Mark Humphrys and Ray Walshe

There is a growing consensus that natural intelligence is likely to be composed of multiple diverse algorithms and knowledge representation formats, with hundreds (or thousands) of specialised subsystems collaborating in some network (or ‘Society of Mind’). This is in contrast to the ‘one size fits all’ approach of many popular algorithms in Artificial Intelligence. If such diverse, extremely hybrid artificial agents are to be built, many authors will need to be involved, each with a different area of specialization. And if the future of AI is one of multiple authors and multiple laboratories building vast collaborative systems, how is this work to be organized?

The World-Wide-Mind project (w2mind.org) proposes that AI research should be organized online, using an agreed, stripped-down, simplified protocol for communication between different subcomponents of the artificial minds. This is related to large online ‘open source’ collaborative projects, but differs from them in that it is not proposed that the components actually have to be open source. In many cases, users of a third party’s subsystem (or ‘sub-mind’) need not understand how it works, but only how to use it as a component in the larger ‘mind’ they are constructing. By keeping the framework as simple as possible and by populating the Web with multiple algorithms, the task of the agent developer is reduced to selecting the algorithms and plugging them into the agent mind. What results are new and novel agent minds composed of many diverse components, designed and implemented by multiple, loosely coupled collaborators.

The project was started in 2001 by Dr Mark Humphrys at Dublin City University, as an attempt to facilitate the integration of the many diverse components of agent minds into whole minds. Though much fascinating research is performed in focused subdomains of AI, such as perception, vision, navigation and language processing, there has traditionally been less effort directed towards the problem of integrating all these components into single, whole agents. Within the past two decades the animat and behaviour-based communities have contributed several modular agent architectures (Brooks’ subsumption architecture

being the best known). These are naturally inclined towards dividing the agent mind into components and integrating the components to create whole minds. Such approaches, generally referred to as ‘Society of Mind’ approaches after Minsky’s famous book, recognize the importance of masking the implementation details of individual components from other components, while retaining a public interface through which they can interact. This reflects the modern approach to software engineering, where modular development is seen to support reuse, maintainability, extensibility and in general the creation of software systems where no individual is required to understand the entire system.

A natural extension of the modular approach in software engineering is the distributed modular approach. Middleware standards such as CORBA and Web Services have provided developers with the means to connect modules over the Internet without knowing anything about remote modules apart from their URL and interface. Although middleware platforms such as JADE (Java Agent Development Environment) provide support for multiple interacting autonomous agents, there has been little or no attention directed towards how the distributed modular approach to software engineering can support the modular implementation of whole agent minds, or how the integration of independent remote components can further our understanding of the diversity required for artificially intelligent agents.

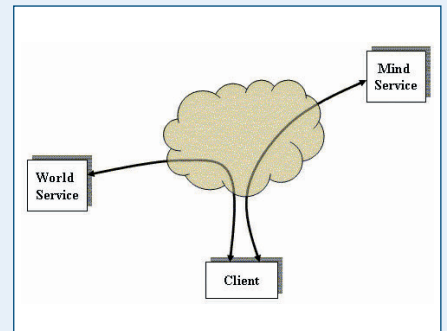


Figure 1: The basic World-Wide-Mind architecture. Client queries both world and mind services for state and action data, passing the required data between the services.

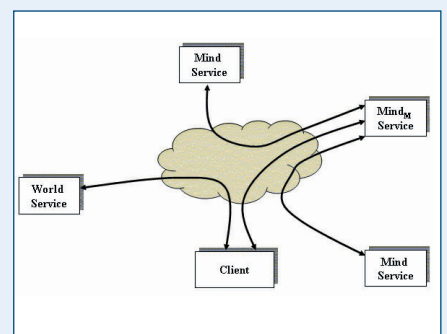


Figure 2: A Society of Mind on the World-Wide-Mind. The MindM service developer creates a switch that selects the appropriate mind service for a given state, delegating responsibility to that service.

The Society of Mind Markup Language (SOML) is the protocol of the World-Wide-Mind (WWM), in much the same way as HTTP is the protocol of the World-Wide-Web. The WWM defines three types of entities, each of which interacts with the others using this protocol.

A world service on the WWM represents some sort of problem, eg a robot in a complex environment, or a creature in some virtual reality. The world service presents a public interface that can be queried for the state of the world (such as the sensory inputs of the creature) and can also be sent an action that the creature should execute.

A mind service represents some action-producing algorithm specifically

designed for a given world service. The mind service will return an action when it is presented with the state of the world. The implementation details of the algorithm are hidden behind the interface, so any state maintained by the algorithm is transparent to the calling entity.

A client is used to plug a mind service into a world service. When launched, the client requests the URLs of the world service and mind service from the user. It then executes a run by querying the world for its state and the mind for its action based on this state, before querying the world again to execute the action. The run iterates through these steps until its natural conclusion (death of the virtual creature, expiration of time permitted for robot), at which point a score is recorded on a publicly accessible scoreboard at the world service.

With multiple online mind services, a third-party developer could select a set of useful mind services and provide a

high-level switch that acts as a mind service, but simply decides at each timestep to which of the multiple mind services it will delegate responsibility. Such switches, named MindM services, facilitate the creation of Societies of Mind, where the many mind services are authored by a diverse set of independent researchers.

The technology required to implement mind services, world services and clients is kept deliberately simple, well below the threshold of knowledge required for complex distributed systems development. SOML entities interact over HTTP, meaning that the creation of a service requires only basic knowledge of Web programming (CGI, Java Servlets, ASP etc).

The framework has been tested with several classes of undergraduate students at Dublin City University and Dublin Institute of Technology. Currently, two world services are online, although since

the protocols are in the public domain, anyone can contribute to the project by developing their own world service, or implementing a mind or MindM service for existing worlds.

A key benefit of the framework is that it is open to all. Complex minds can be built by integrating the product of advanced research by professionals with the novel algorithms of interested amateurs. The result will be complex arrangements of never-before-seen algorithms, possibly bringing us closer to understanding how our own minds and the minds of other animals are made so much richer in the presence of widely diverse components.

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<http://w2mind.org>

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CE-Ants: Ant-Like Agents for Path Management in the Next-Generation Internet

by Otto Wittner and Bjarne E. Helvik

In general, today's Internet can provide only 'best effort' connections, with no quality of service (QoS) guarantees. Both new and popular existing applications and services would benefit from connections with QoS guarantees, eg minimum capacity, maximum delay, continuity of service and availability. How can connections in the Next-Generation Internet (NGI) be managed such that desired QoS guarantees can be provided while the robustness of today's network is maintained? We pursue an approach inspired by the robustness and emergent behaviour seen in swarms combined with stochastic optimization techniques.

One of the fundamental design objectives of today's Internet was connectivity robustness. First of all, two terminals connected to the network should be able to communicate. Secondly, the network should stay operative and provide reliable communication even when a significant number of network nodes and transmission links fail. Hence packet forwarding is controlled in a fully distributed manner and routing units are more or less independent of each other. In this way, the Internet provides connectivity to everybody with a high probability. Unfortunately, no QoS guarantees or differentiations can be given.

Resource Control and Path Management

It is common for network operators to use over-provisioning combined with virtual connections realized by multiprotocol label switching (MPLS), as a way of providing sufficiently low packet losses and delays, load distribution and capacity control. Continuity of service, short downtimes and high availability are obtained by supplementing the traditional Internet restoration techniques with protection switching based on MPLS and/or in the underlying optical layer. These techniques require central-

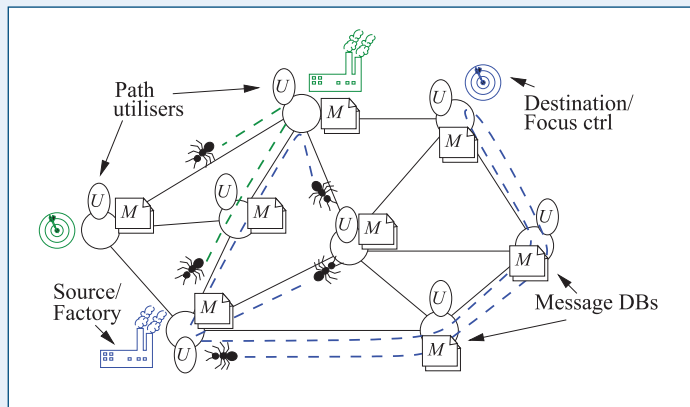
ized planning of resource utilization and path management, which significantly weakens the inherent robustness and autonomy of the traditional Internet.

Furthermore, when multiple paths exist between two communicating terminals, today's routing systems by default forward all packets along the path regarded as having the lowest cost. The exact definition of the lowest cost is generally decided by the network operator, and is not influenced by applications and users. Hence path management does not handle service differentiation. As for MPLS

configurations, cost metrics are set manually and infrequently during centralized planning. Hence it is only possible to consider long-term variation (ie over months to years) in general traffic patterns and topology.

Would it be possible to design a robust path management system that is compliant with the ‘traditional Internet’, that

pairs while seeking to fulfil a set of requirements (the path objective) provided by the owner/producer of the agents. In their simplest form, agents may only be small signalling packets transporting state information. Associating a behaviour with them, however, makes the system description more intuitive. Each node manages a database of messages that are read and updated by the



CE-ant-based path management.

operates on short and medium timescales (minutes to hours), provides controlled QoS differentiation of services or service classes, and enforces operator policies in an optimal way? We believe self-organizing systems inspired by the robustness and emergent behaviour seen in swarms may have the necessary properties to enable such next-generation path management.

CE-Ants

At the Centre for Quantifiable Quality of Service in Communication Systems (Q2S) and the Department of Telematics (ITEM) at NTNU, a set of path management systems is being developed based on a bio-inspired stochastic optimization technique known as Cross Entropy ants (CE-ants). The CE-ant system is a distributed version of Reuven Rubinstein’s popular cross entropy method for optimization. CE-ants have been shown to find near-optimal solutions to NP-complete path-finding problems of large scale. Given its fully distributed nature, it is a promising candidate for path management in the NGI. The figure illustrates the typical components in a CE-ant system. A high number of ant-like agents traverse the network in search of paths between given source-destination node

single node or component is significantly more important than any other. There is no centralized control and no centralized storage of information.

During a single CE-ant agent life cycle, a path is found and reported in the following manner:

1. After visiting a node (initially the factory node) an agent decides which node to visit next by applying a probability distribution. The distribution is based on the agent’s memory of previously visited nodes, the path objective, and the messages (written or updated by other cooperating/competing agents) available in the current node.
2. When reaching its given destination node, ie completing a path, an agent evaluates the cost of the path found and adjusts search focus parameters shared with cooperating agents.
3. Finally, the agent backtracks along the path, writing or updating messages at every node visited. Messages are updated according to the evaluated cost of the path.

After a number of agent life cycles, the overall distribution of messages will converge toward a pattern indicating not only the optimal path but also alternative

close-to-optimal paths. As long as factory nodes produce new agents, the message distribution will be maintained. Hence, if traffic conditions change or link/node failures occur, the optimal path (and the close-to-optimal path) will be updated accordingly. The time scales of such updates are governed by the production frequency in the factory nodes. Finally, any node may initiate a connection set-up by applying the information provided by the message distribution, ie it may regard the message distribution as a distributed routing table and utilize any of the paths found.

Three path management systems based on CE-ants are currently being developed at Q2S and ITEM. *Adaptive restoration ants* simply maintain routing information continuously in a network. Traffic is assumed to be routed (stochastically or along the ‘best’ path) hop-by-hop by applying the information. On failures, traffic is forwarded along ‘second-best’ hops. *Primary-backup ants* find two (link and/or node) disjoint paths between source-destination pairs, meaning they provide 1:1 protection. Back-up paths share capacity. *P-cycle ants* find cyclic paths that may be applied as protection rings. On link and node failures, selected traffic may be switched onto and rerouted around the ring.

A Java-based prototype of a CE-ant system has been developed at Q2S and ITEM. A testbed in the EU-project BISON will soon be ready, in which CE-ants perform monitoring tasks in a system based on Click software routers. These prototypes have shown that only a limited effort is required to realize CE-ant based path management.

Links:

- <http://www.q2s.ntnu.no>
- <http://www.item.ntnu.no>

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ISEE – A Framework for the Evolution and Analysis of Recurrent Neural Networks for Embodied Agents

by Martin Hülse, Steffen Wischmann, and Keyan Zahedi

Complex phenomena like bistability, periodic, quasi-periodic and chaotic attractors can already be observed in small artificial recurrent neural networks. How can such a rich reservoir of emergent properties of neural networks be applied to challenging applications?

We utilize the framework of Evolutionary Robotics (ER) and Artificial Life (AL) to evolve recurrent neural networks (RNNs), which enable robot agents to act successfully in an open and changing environment while mastering a given task. The combination of ER and AL allows the emergence of new control strategies within the sensorimotor loop, as no a priori knowledge is used to bias a possible solution. Hence, it serves as a source of inspiration for research into basic neural structures and general principles of neural signal processing systems, which may find applications beyond robotics.

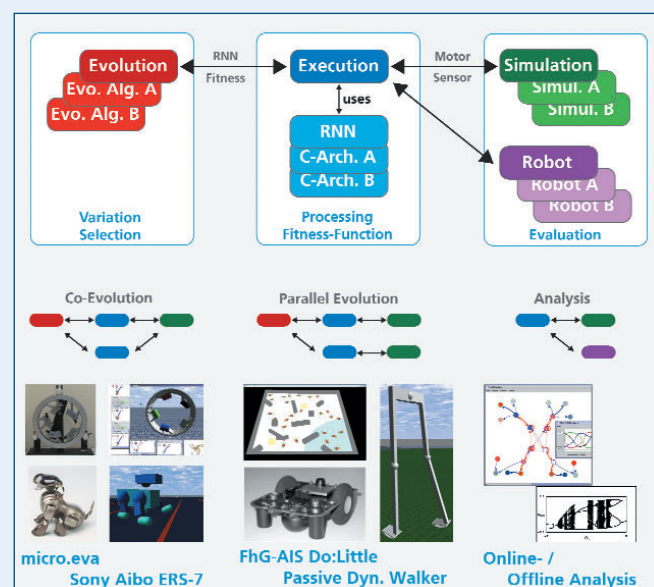
Using a special evolutionary algorithm, the ENS³ (evolution of neural systems by stochastic synthesis) implemented as part of the ISEE package (integrated structural evolution environment, see figure), recurrent neural network structures of the general type for robot control have been developed. The structure and size of RNNs to evolve are open to the evolutionary process, and parameters like synaptic strengths are optimized simultaneously.

The ENS³ can also be utilized to extend or couple existing RNNs to achieve additional functionality. In this way, different behavioural (sub-)functionality can be nonlinearly integrated in one network solving a global robot task. On the one hand, this strategy allows an incremental evolution of complex control structures solving robot tasks, including increasing numbers of subtasks and their effective coordination. On the other hand, such incrementally evolved RNNs give us a wide variety of empirical set-ups with which to investigate multifunctionality and robust behaviour changes in com-

plex systems provided by nonlinear coupled neural systems.

The versatility of our proposed evolutionary environment is sketched in the figure, where some sample applications are shown. A co-evolution strategy was applied for the ring-shaped robot *micro.eva*, where five moveable arms

The wheel-driven robot *Do:Little* is used for experiments in swarm robotics. We used our evolutionary environment to either evolve one controller, which is then homogeneously distributed within a group of up to 150 robots, or for evolving in parallel a heterogeneous set of RNNs, where each individual gets a different RNN. In this way, we evolved



inside the ring must maintain a rotation of the whole body on two passive rollers. Each arm was considered as an autonomous agent. Hence, the neural control for each arm was evolved in parallel but in separated populations. In one result, division of labour could be observed. The same evolutionary strategy was successfully applied to evolve neuro-controllers for the Sony Aibo robot. Here, three different submodules for controlling the forelegs, the hind legs and the coordination of the legs were evolved in parallel to fulfil stable and fast walking patterns.

RNNs for solving cooperative tasks, such as collecting energy and efficient exploration of the environment.

However, the evolutionary environment is not limited to the optimization of neural controllers. We also successfully evolved morphological parameters of a bipedal robot and its neural control at the same time. As a result, we achieved bipedal walking on flat surface with minimal control and high energy efficiency, using its passive dynamics for walking. It only needs to compensate the loss of energy due to friction and heel strike,

which is solved by a comparably small neural controller.

Finally, in the figure one can see a snapshot of some tools that have been integrated into the software package. With tools providing visualization of RNNs and their neural activation during robot-environment interaction, one can gain a deeper understanding of the relationship between neural dynamics and observed behaviour. The dynamic properties of RNNs can also be investigated from a dynamic systems perspective. For instance, one can plot bifurcation diagrams or isoperiodic plots in order to

identify attractors of dynamic systems such as RNNs.

With our software architecture it is possible to evolve different behaviours for arbitrary robotic platforms. One can either use fast simulations or even physical robots for the evolutionary process, as well as for a detailed analysis of control dynamics during robot-environment interactions. Although we mainly applied the ISEE package to robotic applications, it is not limited to the optimization of morphology and control. It can also be applied to various optimization problems unrelated to robotics, such

as function approximation, parameter optimization and so on. The strength of the ISEE package is therefore its versatility and its powerful analysis tools.

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Emergent Intelligence in Competitive Multi-Agent Systems

by Sander M. Bohte, Han La Poutré

Getting systems with many independent participants to behave is a great challenge. At CWI, the Computational Intelligence and Multi-Agent Games research group applies principles from both the economic field of mechanism design and state-of-the-art machine-learning techniques to develop systems in which ‘proper’ behaviour emerges from the selfish actions of their components. With the rapid transition of the real economy to electronic interactions and markets, applications are numerous: from automatic negotiation of bundles of personalized news, to efficient routing of trucks or targeted advertisement.

In an economic setting, an individual - or agent - is assumed to behave selfishly: agents compete with each other to acquire the most resources (utility) from their interactions. In economics, the field of mechanism design looks at interaction protocols (mechanisms). Here, the combined selfish behaviour of individual agents serves a particular purpose as an emergent property of the system: for example, the efficient allocation of scarce goods. Many computational problems can be cast as resource allocation problems. Our research transfers the emergent property of human competitive multi-agent systems to systems comprised of competing pieces of software, ie software agents.

Clearly, software agents in a multi-agent system must be intelligent and adaptive. If intelligent software agents are to work out the (local) solutions that are best for themselves, the rules of the system must be incentive compatible. That is, the



Competitive multi-agent games: to each its own.

rules should be such that as individual agents learn how to optimize their own reward, the system as a whole should work with increasing efficiency. Our work shows that the combination of intelligent software agents and well-designed mechanisms (markets/auctions/negotiations) can lead to the desired behaviour of the system as a whole, a kind of ‘collective intelligence’.

For example, we designed a personalized recommendation system in which competing advertising agents can bid for the attention of the customer. The design of the market, combined with adaptive intelligence in the bidding agents, results in the emergent effect that only the most relevant advertisements are shown to the system user.

In a similar vein, we considered the dynamic scheduling of trucking routes and freight. We developed a dynamic spot market where a software agent in each truck continually participates in auctions to increase, change and augment the loads the truck carries. To facilitate this, we developed bidding strategies for repeated auctions where the software agents compute which combination of loads they can acquire most profitably. We show that as an agent tries to best anticipate future loads with the aim of improving its own profit, an emergent effect is that the market as a whole

becomes more efficient and the cost of transport is reduced.

Within the same paradigm, we developed methods for dynamically pricing information. Electronic information can be sold to many buyers at the same time. If we demand that each buyer pays the same price, the problem is what the price should be. In our system, we show how the selling agent can deduce the pricing policy that will maximize revenue from the aggregate of negotiations between the seller and the buyers (one-to-many).

This method has been extended by integrating recommendations in a negotiation process. A shop aggregates data on customers' past purchases, and produces information on correlations on customer interest in the products on offer. For instance, which products are often bought together? We applied machine-learning techniques to the problem of online learning of the bundle combinations that optimize the revenue of a seller of information goods. When negotiating with a new customer the price of a bundle of such products, the shop uses this learned knowledge to recommend alter-

native, more promising bundle compositions if the negotiation process stalls. We designed and implemented a combined system for making recommendations during a negotiation. Extensive simulations with this system show superior performance on a number of benchmarks.

Related to these logistics applications is the use of emergent competitive agent systems in health-care logistics. In a project on medical information agents, we have researched the problem of patient treatment scheduling in hospitals. Scheduling complex treatment plans requires coordination between all the relevant autonomous departments. Due to the dynamic nature of a hospital, any approach must be efficient, online and flexible. In cooperation with medical experts we are investigating the use of autonomous software agents negotiating with each other in order to make (or reschedule) appointments for patient treatment. The idea is that as each agent follows its owner's interests and preferences, agreements over schedules can be reached that take into account all the individual constraints. Thus, a good

schedule should emerge from the agent interactions.

Obviously, systems where many self-interested stakeholders interact pervade our society. Neglecting the strong incentive these stakeholders have to be selfish can be catastrophic for the functioning of any system that tries to bring these parties together electronically. At the same time this is also a great opportunity, since we can rely on individual agents to maximize their own utility. Thus, we can design the system to encourage 'emergent intelligence', as individual intelligent behaviour continually improves the workings of the system as a whole. There are many opportunities for smarter software agents and better mechanisms, such as emergent multi-agent scheduling. We are actively pursuing this in current research.

Link:

<http://www.cwi.nl/sen4>

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Building a Computational Digital Economy through Interdisciplinary Research

by Petros Kavassalis and Konstantin Popov

Researchers from the Swedish Institute of Computer Science (SICS) and the ATLANTIS Group at the University of Crete are forming a multidisciplinary team to study the complex issues of consumer decision-making in the online world. Their approach combines modern computer modelling and simulation methods with techniques from the emerging field of neuroeconomics.

Consumers on the Web take advantage of the fact that information is available in excess. They search and gather product information, compare prices and check product availability. They access free reviews in online consumer forums and share product experience in slashdot-like agoras. Several economists are now talking about a new marketing world in which consumers enjoy a superior information endowment, and suggest that businesses should adopt high-differenti-

ation strategies as a way of reducing the importance of price in consumer choice.

This 'information excess' introduces a significant effect: the process of information perception and evaluation might determine, almost 'bias', the entire consumer decision-making process. Consumers on the Web will increasingly have a quasi-realistic experience with products, and may make their decision over the Web alone. In addition, various self-reinforcing, information-propaga-

tion mechanisms, such as the Online Feedback Mechanisms, enable a complex choice process and act as positive feedbacks into consumer choice behaviour.

In studying such a complex system, there are many questions to be answered. How are individual preferences being constructed and developed? How do these preferences become coherent in such an information-rich environment? Does the 'information excess' increase

or decrease the uncertainty with respect to the value one should give to various product attributes? What is the impact of previous consumer experience, if any, on preference stability? How efficient can online feedback mechanisms be in making consumers organizationally effective and creative under these conditions? The challenge is to develop behavioural models that can help to understand how consumers make choices in information-rich environments, and to investigate efficient cyber-consumer welfare policies and effective business strategies in online markets.

Modelling Digital Economy

Algorithmic game theory can provide mechanisms for understanding how online agents with diverse objectives can coordinate adaptively and arrive at a stable equilibrium. Alternatively, complex systems methods allow for a greater variety of individual behaviour and for simplicity with respect to the reasoning attributed to the individuals. In addition, they allow for individual preferences and interaction links between individuals to be embedded in networks and distributed across the population with non-uniform probability.

Computer-based modelling and simulation can be used to study online markets as 'non-cooperative games'. Neuroeconomics can help to investigate the physical mechanisms by which the human neuroarchitecture accomplishes product selection in the online world. These two areas together can yield very realistic behavioural models of 'intelligent' agents representing cyber-consumers. The structure of these agents will be more than a framework for implementing rational or steady-state adaptive behaviour, and will reflect the organization of the mind when consumers make decisions. Hence, it is expected to: (i) possess capabilities that single out particular product attributes as meaningful, (ii) take into account advice from other consumers, and (iii) feature proactiveness and deploy internal commitment ability. Agents' structure should therefore include a number of cognitive elements (sensation, cognitive control, learning, memory, processes for social behaviour etc) and a cognitive architecture, such as ACT-R (see Links) that

coherently integrates components. Decision-making will arise from the interaction of these cognitive processes, as constrained by the architecture.

Intelligent Agents

'Intelligent' cyber-consumer agents reason about products which, in turn, are represented as vectors of different functional characteristics. This allows for product differentiation extending far beyond typical spatial differentiation, with uniformly distributed consumer preferences and products that are spatially differentiated along a simple unit circle. Finally, we model the strategies of online marketers to be associated with products and exerted to influence the competition game.

Simulation of these models will generate highly dynamic, non-linear, experimental online markets with a high density of circular dependencies and information flows, the study of which can enrich our understanding of real Web markets. Data from the real Web, such as product listings with full descriptive characteristics, and product rankings taken from online forums, should be integrated into the system during simulation, making the world in which our artificial agents live more realistic. Pursuing this line of experimentation, the simulation of a digital economy is intended to effectively reproduce several structural properties of the real Web, and unfold drivers for the Web's deployment and growth to identify causal (economic) forces at work that affect its design.

Integrating Data into Simulation

Two types of data can enhance simulation. The first is information on the possible behaviour of cyber-consumer agents, collected through neuro-experiments with volunteer participants acting in quasi-realistic conditions. The second is data collected from the real Web that will be used to populate the local environment of the individual agents. This environment is, of course, altered by the agents' actions during the course of the simulation. We propose to use a simple(r) model of the system as the context for analysis and exploitation of data. Whenever state and inputs of a simulated agent match the available data, its outputs should also match the data. Analysis

can include inferring relationships between elements of data, validation of hypothesized models of individual agents produced by model designers, and maybe even automated generation and calibration of models using machine-learning techniques. In this context, analysis of data and validation of models of agents become integrated into the agent-based simulation. Learning of agent behaviour through simulation has already been proposed by 'participatory simulation', where humans substitute for model agents during simulation runs. However, participatory simulation deals with humans that entirely substitute for model agents, whereas in our case, both experimental and publicly available data are analysed and continuously used during 'pure' agent-based simulation.

A general-purpose concurrent programming system like Mozart, can be used as a platform for developing simulations with cognitive agents and integration of real-world data. Model agents are conceptually concurrent. Their concurrent implementation can be exploited for distributed/parallel execution aiming at scalability and performance, which becomes crucial with large-scale, computationally intensive models. Integration of cognitive architectures and data analysis into model agents requires flexibility of a general-purpose programming language.

Links:

<http://www.c2.org/>

ACT-R: <http://act-r.psy.cmu.edu/>

Mozart: <http://www.mozart-oz.org>

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Models of Multilateral Cooperative Behaviour

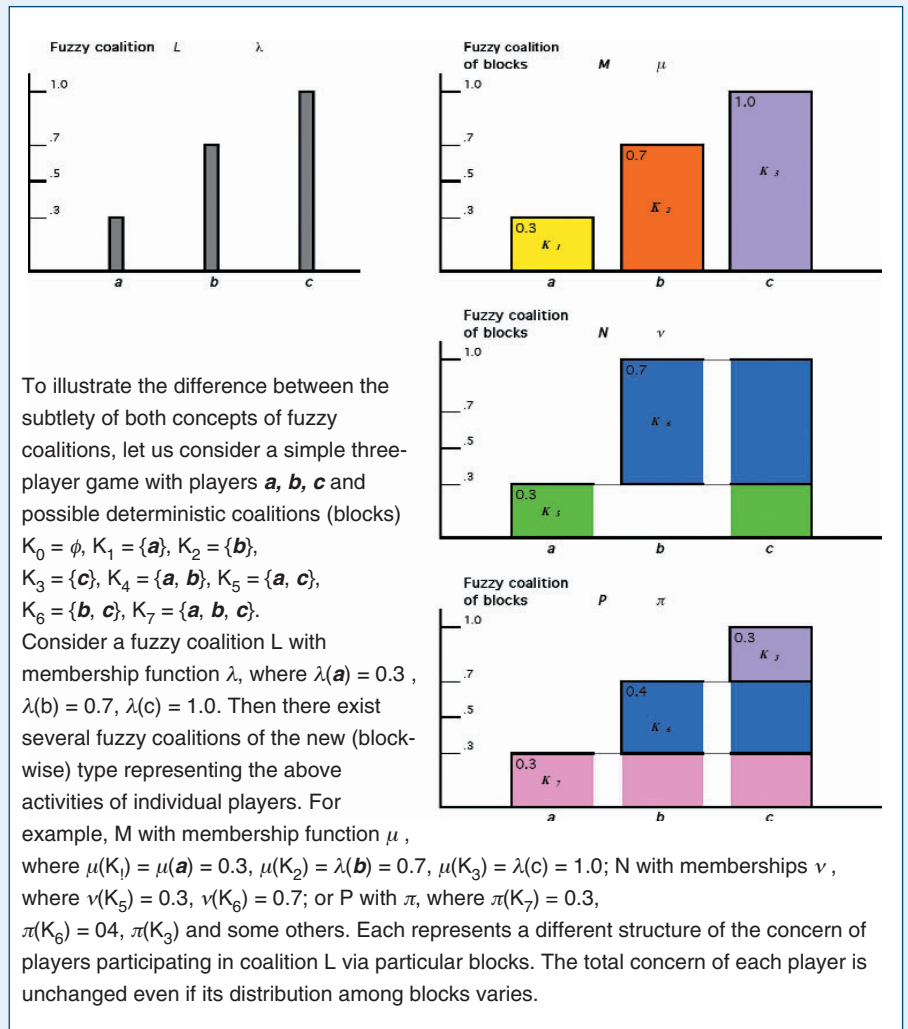
by Milan Mareš

The concept of artificial intelligence includes the possibility of cooperation between its representatives (eg robots, complex man-machine systems or other structures), where each is attempting to maximize the values of its goal function. Such an endeavour is formally defined as a cooperative game in which players coordinate their strategies in order to maximize the individual pay-offs for each of them. After a long period of investigation into deterministic games, our attention has recently been focused on games in which the cooperation is distributed among several parallel interests.

The classical theory of cooperative games assumes that, after the negotiation period, the set of players separates into disjoint coalitions and each player participates in exactly one of them. This assumption is not realistic – in real communities with non-trivial structure, regardless of whether their members are human beings or coordinated artificial decision-makers, each member simultaneously follows several goals, distributing its ‘power’ among them. To achieve these goals, the player cooperates with several groups of partners. Such distributed cooperation is usually modelled by fuzzy coalitions, which have been investigated since the early eighties.

The classical model defines fuzzy coalition as a fuzzy subset of the set of all players. This approach displays many advantages, but also has some problems. The fundamental nature of these becomes evident when the formal model is to be compared with its intuitive interpretation. For example, such a concept of fuzzy coalitions practically excludes their disjointness (the classical fuzzy set theoretical disjointness practically eliminates the multilaterality of cooperation). Consequently, it eliminates also the principle of superadditivity and related game-theoretical concepts specifying the distribution of the coalitional pay-offs.

This recent research was supported by grants from the Grant Agency of the Czech Republic No. 402/04/1026 and the Grant Agency of the Academy of Sciences of CR No. A1075301. Its goal was to suggest an alternative model of cooperative behaviour with distributed cooperation, better reflecting the super-additivity and related properties of fuzzy coalitions. The main motivation was to



Fuzzy coalitions.

find an adequate model of the complex structure of the cooperative relations divided into several fields of interests.

The suggested alternative approach is based on the definition of a fuzzy coalition as a fuzzy subclass of the class of all deterministic coalitions (ie of all subsets of the set of all players; in this model, called ‘blocks’). This approach reflects

the fact that players usually divide their ‘power’ (investments, energy, social contacts, authority etc) among several interests in which they cooperate with equivalent (similarly motivated) partners. These blocks enter the conflict as relatively compact units and the total incomes of particular players comprise the sum of their incomes from each block. Each block can be active in sev-

eral fuzzy coalitions. In this sense, the disjointness concept can be simplified: the simultaneous participation of a player in several fuzzy coalitions (intermediated via his participation in different blocks) does not impair their disjointness if he acts in them as a member of different blocks.

This model displays certain advantages. One of them is the formal simplicity of

the definition of superadditivity, subadditivity and convexity, with interesting consequences for the concept and properties of the core and other solutions. Another, perhaps even more interesting advantage is that the alternative model offers much more sophisticated tools for the characterization of the cooperation. It is easy to see that the classical fuzzy coalitions can be transformed into several fuzzy coalitions of the new type.

They reflect in some sense similar relations among players, but offer many more details regarding the subtle differences of their inner structure.

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Emergent Walking Behaviour in an Aibo Robot

by Cecilio Angulo, Ricardo A. Téllez and Diego E. Pardo

A totally distributed neuro-evolved architecture, designed for the general control of autonomous robots, has been employed for the emergence of walking behaviour in the 12 degrees of freedom (DOF) quadruped robotic Aibo dog. The concept of central pattern generators in animals is bio-inspired, and is used to obtain the desired walking robot. Moreover, the search to dissolve the ‘Body-Mind’ problem is our inspiration.

Our project is focused on the reactive interpretation of the mind, so we are interested in the emergence of certain behaviour. Quadrupedal walking is a complex task. In a robot like Aibo, there are twelve degrees of freedom, and their coordination to obtain a walking pattern becomes very difficult. To deal with this problem, the Knowledge Engineering Research Group (GREC) at the Technical University of Catalonia (UPC) has designed a neuro-evolved controller for the Aibo robot using neural networks distributed all over the robot. We have based our neuro-control system on Central Pattern Generators (CPGs).

Biological CPGs are composed of groups of neurons that produce oscillatory signals without oscillatory inputs. It has been discovered that the walking movements of cats and dogs are governed by such elements, and it is thought that humans behave in the same way. We implement artificial CPGs using artificial neural networks (ANNs). To overcome the problem of capturing the dynamics of the system, we have used continuous-time recurrent neural networks (CTRNNs).

The proposed distributed neuro-evolved architecture is based on several uniform

modules known as Intelligent Hardware Units (IHU). These can be designed around any physical device in the robot (sensor or actuator). Figure 1 illustrates a simplified two sensor/two actuator architecture.

Through the use of a neuro-evolutionary algorithm, modules learn how to cooperate and how to control or interpret their associated elements, thereby allowing the whole robot to learn how to walk.

It should be stated that when several IHUs work together on a control task, each element has its own particular view of the situation, since each is in charge of a different sensor or actuator. This leads to a situation where each unit uses its knowledge both of the global situation and of its particular device to decide what its next action will be.

In this way, the traditional ‘Mind-Body’ problem can be dissolved. Control of the process is performed through three elements (modellers, controllers and translators). These elements must adapt the relationship between the ‘body’ (embodiment) and the ‘environment’ (situatedness).

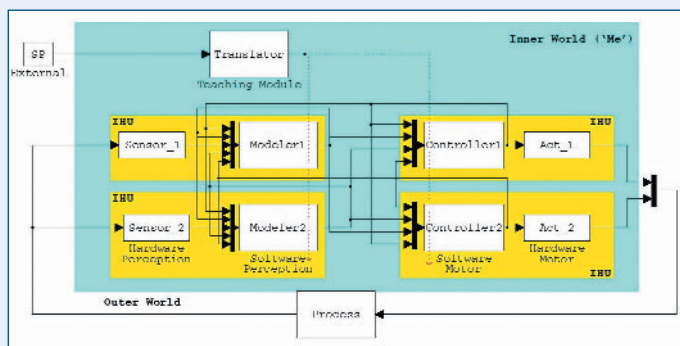


Figure 1: ‘Me’ depends on the ‘task’ (task-directed training) as interpreted by the translator; on the ‘environment’ (‘outer world’) interpreted by the modeller; and on the ‘body’ (‘inner world’, sensor and actuator), acting through the controller.

modules known as Intelligent Hardware Units (IHU). These can be designed around any physical device in the robot (sensor or actuator). Each IHU is composed of a sensor or an actuator and a micro-controller that implements an ANN. The ANN processes

The modeller is a control element that tries to adapt what the sensor ‘sees’ from the ‘outer world’ to what the cerebrum ‘sees’ in its ‘inner world’ by also considering the actions of the controller. Is it the nervous system? In any case, it undergoes continuous learning in order to adapt the body to the environment.

The translator is a control element that tries to translate the external set point (a behaviour associated to a task) as an interpretation of the ‘outer world’. Is it the behavioural system? In any case, it is the learning function for the whole ‘inner world’ system.

The controller is a control element that deals with both, the internal perception of the ‘outer world’ (sensor) in the form of the ‘inner world’ units (modeller), and the task to be accomplished (external set point) translated to a internal set point, also in the ‘inner world’ units (translator); then appropriated commands are



Figure 2: Aibo walking sequence.

sent to its associated actuator. Is it the cerebral neural network? In any case, it must drive the actuator changing the body/environment situation.

Until now, embodied AI approaches have focused on lower-level aspects of the behaviour related to their embodiment; this is the reactive interpretation of the mind. However, our proposed distributed architecture is able to accomplish complex tasks, like the walking behaviour of the 12 DOF Aibo robot (Figure 2), by dissolving the ‘mind-body’ problem. The next stage in this project is to extend the architecture so as

to be able to model higher-level behavioural aspects. In this way we avoid hybrid models that integrate both a ‘deliberative’ and an embodied ‘reactive’ component.

Links:

http://www.ouroboros.org/evo_gaits.html
<http://www.upcnet.es/~upc15838/>

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Concept-Based Text Representations for Categorization Problems

by Magnus Sahlgren

Standard practice in most of today’s research on text categorization is to represent texts simply as the bag of words they contain, ignoring both syntax and semantics. As an alternative to this, we have developed a novel form of text representation that we call Bag-of-Concepts, which constitutes a distributed representation of the concepts contained in a text.

Overwhelmingly, the most common representational scheme in text categorization research is the Bag-of-Words (BoW) approach. Here a text is represented as a vector whose elements are frequency-based weights of the words in the text. These BoW vectors are then refined, by feature selection for example, meaning words are removed from the representations according to statistical measures such as document frequency, information gain or mutual information. Another refinement method is to use feature extraction. In this case, ‘artificial’ features are created from the original ones, either by using clustering methods such as distributional clustering, or by using factor ana-

lytic methods such as singular value decomposition.

It is important to note that feature extraction methods handle problems with word variability by one of two methods. Either they group together words that mean similar things, or they restructure the data (ie the number of features) according to a small number of salient dimensions, so that similar words get similar representations. Since these methods do not represent texts merely as collections of words, but rather as collections of concepts - whether these be synonym sets or latent dimensions - we suggest that a more fitting label for these representations is Bag-of-Concepts (BoC).

One serious problem with BoC approaches is that they tend to either be computationally expensive or require external resources such as dictionaries. To overcome this problem, we have developed an alternative approach for producing BoC representations based on Random Indexing (see ERCIM News No.50, July 2002). This is a vector space methodology for producing ‘context vectors’ for words based on co-occurrence data. Very simply, this is achieved by first assigning a unique random ‘index vector’ to each context in the data. Context vectors are then produced by summing the index vectors of the contexts in which words occur. (For an introduction to random indexing, see

http://www.sics.se/~mange/random_indexing.html). The point of the context vectors is that they represent the relative meanings of words; they can also be used to compute the semantic similarity of words.

We use the context vectors produced with random indexing to generate BoC representations by summing the (weighted) context vectors of every word in a text. The resulting BoC vectors are effectively combinations of the concepts (ie word meanings) that occur in the text. Note that the representations are produced using standard vector addition, which means that their dimensionality never increases even though the data might grow: the dimensionality of the vectors is a parameter in random indexing. Since we typically choose a dimensionality much lower than the number of words and contexts in the data, we also achieve a reduction in dimensionality as compared to the original BoW representations.

To evaluate the BoC representations, we have used them for text categorization, which is the task of assigning a text to one or more predefined categories from a given set. Our experiments use a support vector machine classifier for a standard text categorization collection, and we have shown that the BoC representations outperform BoW with 88.74% vs. 88.09%, counting only the ten largest categories. This suggests that BoC representations might be more appropriate to use for large-size categories.

Our experiments also showed that it is always the same categories that are improved using BoC. This suggests that we might be able to improve the performance of the classifier by combining the two types of representations. When doing so, the result improves from 82.77% to 83.91% for all categories. For the top ten categories, the result improves from 88.74% to 88.99%. While the difference is admittedly small, the increase in performance when combining representations is not negligible, and indicates that concept-based text representations deserve further study.

Link:
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A Framework for Efficient Statistical Modelling

by Daniel Gillblad and Anders Holst

Researchers at SICS have developed a new framework for statistical modelling, which can effectively describe complex probability distributions over a large number of attributes of mixed type. This can be very useful when building adaptive models of complex real world data.

In emergent computing it is important that real world data are modelled in an appropriate way. This means that the model should represent the relevant aspects of reality in a way that is robust, adaptable and data driven. Simple linear regression models are usually not powerful enough to model complex real world data. We have developed a very general framework for statistical modelling, which can effectively describe complex probability distributions over a large number of attributes of mixed type.

In a graph model, a distribution over many attributes is expressed as a product of factors, each involving distributions over much smaller number of attributes:

$$f(x) = \prod_i \psi(u_i)$$

By hierarchically combining mixture models (sums) and graph models (products), we have a powerful modelling framework capable of expressing very complicated distributions.

The Hierarchical Graph Mixtures Framework

The modelling framework, *Hierarchical Graph Mixtures*, is based on a combination of mixture models, probabilistic graph models, and Bayesian statistics.

In a mixture model, a complex distribution is represented as a sum of simpler distributions,

$$f(y, z) = \sum_{i \in S} \pi_i f_i(y|z)$$

Figure 1 shows a simplified view of the complementary nature of mixture models and graph models. A mixture splits the data into subsets of samples, $\{\gamma_1, \gamma_2\}$ etc. The graph model instead groups attributes, eg $\{x_1, x_2\}$ and $\{x_2, x_3\}$. By building hierarchical models, we can construct arbitrary groups of attributes and samples. For example, we can use different dependency structures within different clusters of the data.

The meta-structure of the model (ie where to use graphs and where to use

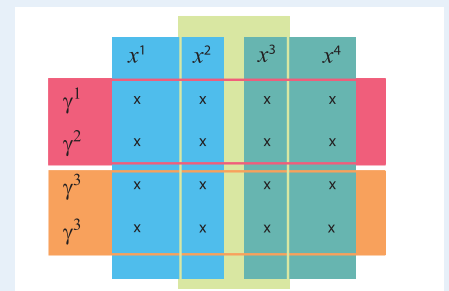


Figure 1: A simplified view of the complementary nature of mixture models and graph models.

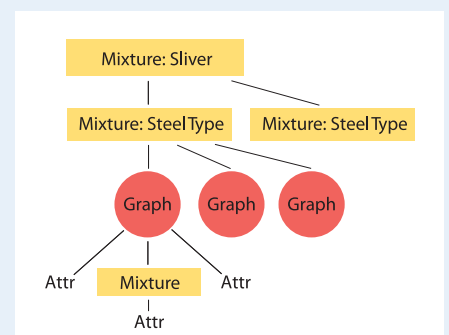


Figure 2: The model structure of the sliver detector.

mixtures) is specified manually. Thereafter all parameters of the model are trained from data, including graph structures and mixture partitions. To make training and usage of arbitrary hierarchical structures work, all operations on mixtures and graphs are expressed in such a way as to be independent of the form of the sub-distributions. This also provides for a straightforward implementation of the modelling framework. All parameter estimation is performed using Bayesian statistics to ensure stability.

An Application Example

An example of the application of this model is in the hot steel mill Outokumpu Stainless AB in Avesta (formerly

AvestaPolarit). The task was to identify which steel coils are at risk of surface damage (or ‘slivers’). There were about 270 attributes to consider, both continuous and discrete. Furthermore, it turned out that different steel types had significantly different sensitivities to slivers.

In this case we used the hierarchical graph model at its extreme. We built a mixture with one model for non-sliver cases and one model for sliver cases, and within each of these we built a mixture model over each of eight different steel types. Within each of these we modelled the data over the 270 attributes with a graph model, and finally, in the graph model we sometimes had to make a joint

model over one continuous and one discrete attribute, which was again realized as a mixture. So in effect we had a mixture model of mixture models of graphs of mixture models over the attributes. An overview of the model is shown in Figure 2. This seemingly complicated model manages to improve the accuracy twenty-fold in identifying which steel coils are at risk of getting slivers.

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Rules, Inferences and Robust Approximation at Work

by Antonín Dvořák, Vilém Novák, Viktor Pavliska

How can a computer be taught to act like an experienced human being in complex situations? What sort of human-readable information can be extracted from numerical databases? Can we obtain new robust methods for approximation of functions and for solving differential equations? In addition, can we apply them, for example in signal filtering, compression and fusion of pictures, or the determination of ancient sea levels, when only very imprecise data are available? Soft computing methods are able to provide all of these, and even more.

Soft computing is a scientific discipline in which methods are developed that work effectively in presence of indeterminacy (ie imprecision and uncertainty), and provide practically optimal and inexpensive solutions in situations where only rough, imprecise information (very often expressed in natural language) is available.

Soft computing has been studied at the Institute for Research and Applications of Fuzzy Modelling (IRAFM) at the University of Ostrava in the Czech Republic for several years. In particular, two concepts have been investigated both theoretically and experimentally: fuzzy IF-THEN rules and fuzzy approximation. Recall that the former take a form such as “IF salary is more or less small AND quality of house is medium THEN mortgage coefficient is rather small”.

Sets of fuzzy IF-THEN rules represent linguistic descriptions of control, decisions and other complex situations. We model these rules using formal fuzzy logic, with a strong emphasis on proper linguistic treatment of the expressions contained within them. This is accomplished by means of:

- careful study of evaluating linguistic expressions (eg ‘small, more or less high, approximately 26, roughly medium’, etc). Such expressions are indispensable in human reasoning
- interpreting fuzzy IF-THEN rules as linguistically expressed logical implications (the theoretical framework is higher-order fuzzy logic)
- using a special inference method called Perception-based logical deduction.

The methodology enables us to communicate with the computer in (restricted) natural language, without needing to penetrate into the fuzzy logic machinery.

The computer acts (performs inferences) similarly to a human such that it resembles a specific ‘human partner’. We can also model sophisticated human reasoning, such as that accomplished in detective stories or complex decision-making.

Linguistic descriptions can be obtained from experts, or by learning from data, or by combination of both. For example, linguistic knowledge (in a human-friendly form) can be extracted from databases for complex queries containing vague notions. Another possibility is to build a linguistic description from a successful course of control, eg of a technological process, mobile robot etc. Using our methods, we can also search the so-called linguistic associations in numerical data, eg “a significantly small crime rate AND a large proportion of residential land IMPLY more or less medium housing value”. Such associations characterize relations in the data in

a way that is closer to the way of thinking of experts from various fields.

Fuzzy approximation is a class of methods for the approximation of classical functions using techniques of soft computing. We have elaborated approximation methods using relational interpreta-

tion of fuzzy IF-THEN rules and developed a new method called the fuzzy (F)-transform. This is a powerful method for approximating functions, which has a wide variety of applications, eg in signal processing, approximate solutions of differential equations (ordinary as well as partial), or in methods for the compress-

sion and/or fusion of pictures. Our methods are very robust, that is, they have a low sensitivity to changes in the input data (eg signal filtering depends very little on sampling).

Our software system LFLC (Linguistic Fuzzy Logic Controller) deals with linguistic descriptions and enables fuzzy approximation; an interface to MATLAB/Simulink is also available (see Figure 1). A large-scale application of our methods can be found in Kovohut\{e} B\{r}idli\{c}n\`a, in the Czech Republic, where LFLC controls five massive aluminium furnaces.

IRAFM is a partner of the Research Centre DAR (Data/Algorithms/Decision Making), headed by the Institute of Information Theory and Automation of the Czech Academy of Sciences (an ERCIM member). Our goals in DAR include fuzzy modelling of complex processes (where linguistic descriptions play a key role) and a combination of stochastic and fuzzy models.

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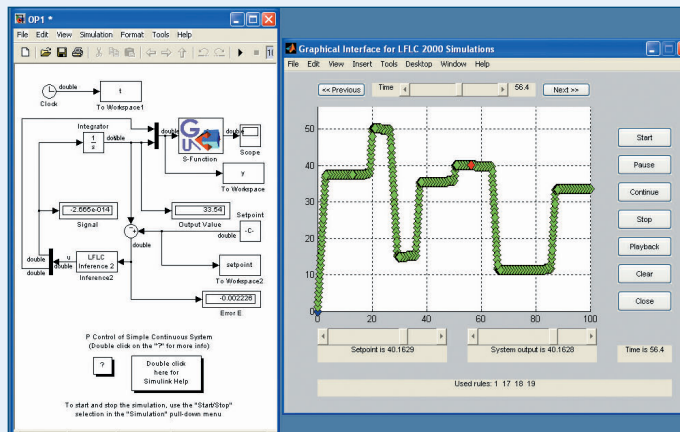


Figure 1: Simulink interface of LFLC - simulation of control of simple dynamic system.

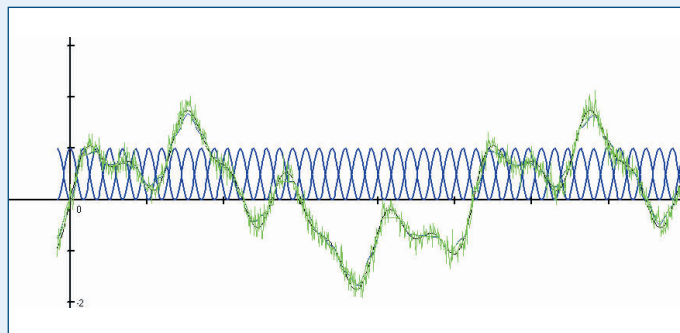


Figure 2: Demonstration of filtering abilities of F-transform.

Particle Swarm Optimization for the Reconstruction of Permittivity Range Profiles from Microwave Measurements

by Simone Genovesi and Emanuele Salerno

At the Signal and Images lab, ISTI-CNR, we are developing a new algorithm to reconstruct the permittivity range profile of a layered medium from microwave backscattering data. The algorithm is based on a particle swarm strategy to optimize a specific edge-preserving objective functional. Our technique is able to efficiently find the global optimum of the objective functional, while preserving the discontinuities in the reconstructed profile.

Inverse scattering is relevant to a very large class of problems, where the unknown structure of a scattering object is estimated by measuring the scattered field produced by known probing waves. As illustrated in Figure 1, several application areas are involved, such as civil

and industrial engineering, non-destructive testing, medical imaging and subsurface inspection. However, a truly satisfactory solution to the inverse scattering problem has not so far been found owing to its intrinsic ill-posedness. Common inversion techniques are either highly

sensitive to noise or produce over-smoothed profiles by enforcing global constraints. This is a major drawback, since the discontinuities carry essential information on possible heterogeneous inclusions in the building material, and maintaining them in the reconstructed

profile is very important. Moreover, the nonlinear relationship between the scattered field and the object function, and the robustness of the inversion algorithms, are still open issues and most scattering tomography techniques are not sufficiently reliable to solve practical problems.

Our current purpose is to reconstruct one-dimensional permittivity range profiles of architectural objects from microwave backscattering data on a certain frequency range. The complete iterative procedure involves a forward solver and an optimizer.

The former computes the backscattered field from the currently proposed solution. The latter uses the results from the solver plus some a priori information to drive the optimization process. We have chosen to discretize the wall into a finite number of homogeneous and lossless layers of equal thickness (see Figure 2). It is assumed that the total thickness of the wall is known and the incidence of the probing waves is normal.

In order to estimate the wall permittivity as a function of the depth coordinate z , we build a functional containing two distinct terms. The first is a suitable distance between the measured and the calculated backscattering data. The second is a combination of a quadratic, first-order, smoothness constraint and an explicit smoothness-breaking term, which preserves possible abrupt permittivity variations where these are likely to occur.

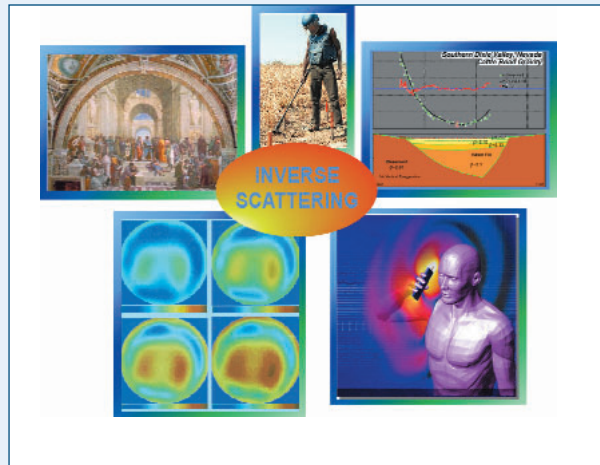


Figure 1: Inverse scattering has a wide range of applications.

Our unknowns are the permittivity values of all the layers and the locations of possible discontinuities. To optimize the objective functional, we are implementing a particle swarm algorithm. Particle swarm optimization (PSO) is an evolutionary computation technique inspired by the social behaviour of flocks of birds and swarms of insects. In PSO, each solution is represented by an agent, or particle, which explores the multidimensional solution space.

During the search procedure, the agents change their positions over time by flying around in the solution space. Since we adopt a fully connected swarm topology, each agent knows the best location found by the rest of the swarm, and is able to adjust its velocity according to its own experience and the experience of all the other agents. As a result, any agent is stochastically attracted towards both its own best location and the best location

found by the swarm, and is able to evaluate the status of its current location. The initialization of the position and velocity of each agent is random. We are now running some preliminary simulations to test different swarm sizes and other initialization procedures, and to tune the parameters involved in the velocity update (eg particle inertia, and social and cognitive rate).

Our first results have been encouraging. Figure 3 shows a simulated profile with large discontinuities, and its reconstruction from noisy data as obtained by our swarm algorithm. The wall was assumed to be 24cm thick and was subdivided into twelve layers. Note that the permittivity values are large (this structure could model a concrete wall with an internal air inclusion). This means that our test object is strongly scattering, and many other inversion techniques would have failed to reconstruct it.

This research is conducted within the framework of a project financed jointly by the Italian National Research Council (CNR) and the Italian Ministry of Education and Research.

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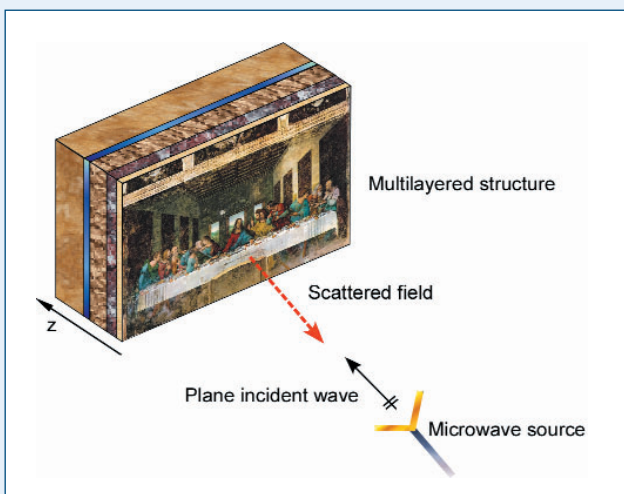


Figure 2: Interaction between the multilayered structure and the microwave radiation.

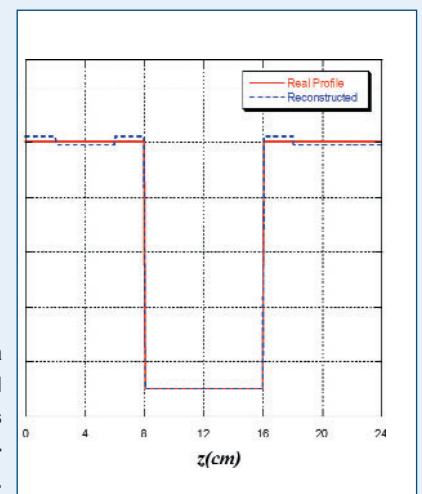


Figure 3: Results from a simulated discontinuous profile (25 dB-SNR data).

Building Blocks from Biology for the Design of Algorithms for the Management of Modern Dynamic Networks

by Gianni A. Di Caro, Frederick Ducatelle, Luca Maria Gambardella, and Andrea Rizzoli

Modern computer and communication networks are becoming increasingly large, heterogeneous and dynamic. Traditional network algorithms fail to deal efficiently with this increased complexity. The EU-funded project BISON addresses this problem by drawing inspiration from biology to provide the building blocks for a new family of distributed, self-organizing, adaptive and scalable network algorithms.

Biology-Inspired techniques for Self-Organization in dynamic Networks (BISON) is a three-year Shared-Cost RTD Project (IST-2001-38923) funded by the Future and Emerging Technologies activity of the Information Society Technologies Program of the European Commission. It runs from January 2003 until December 2005. The BISON consortium draws on multidisciplinary expertise from the University of Bologna (Italy), which is the coordinator, Dalle Molle Institute for Artificial Intelligence (IDSIA) (Switzerland), the Technical University of Dresden (Germany) and Telenor AS (Norway), which is the industrial partner.

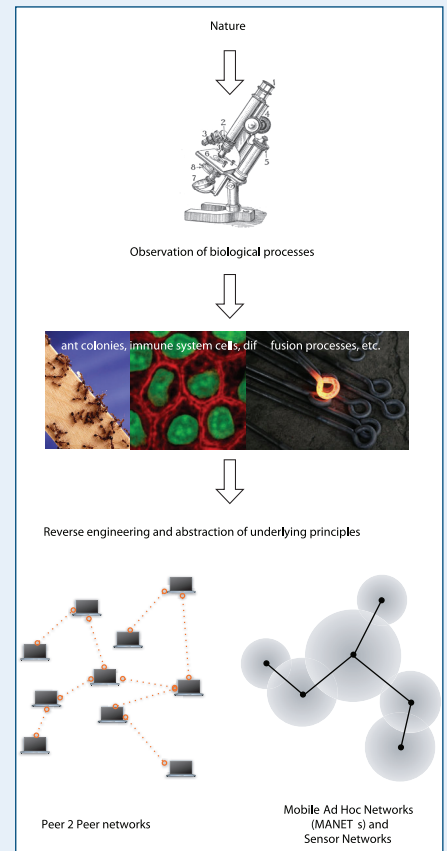
The objective of BISON is to develop new network algorithms that are adaptive to changes, robust to failures and perturbations, work in a self-organized and decentralized way, and are able to function efficiently in heterogeneous large-scale systems. Central to BISON's approach is the idea of drawing inspiration from biological systems to develop this new family of algorithms. The rationale behind this choice comes from the following observations. Biological systems usually have the ability to effectively adapt to constantly changing environments. Moreover, they are usually robust to internal perturbations or loss of units, and are able to survive and evolve in a wide range of environments.

Biological systems have obtained these properties through evolution: they are usually composed of a large number of dynamic, autonomous and distributed units, which display effective adaptive

behaviour at the system level as a result of local interactions and self-organization. Examples of systems showing this highly complex behaviour are ant colonies, and the cells of the human immune system. Because of these appealing properties, natural systems have served as a source of inspiration for a number of successful algorithms and frameworks, mainly for optimization tasks (eg evolutionary computation and ant colony optimization). The application of the biological approach to network problems has attracted relatively little attention. However, the analogy between networks and natural systems is evident: the nodes of a network environment can be seen as the units of a biological system, and the actions and input/output of users form the external environment.

The BISON research intends to exploit this analogy. We investigate biological processes in a systematic way, and abstract and reverse-engineer the basic mechanisms at work. This allows us to identify building blocks for the design of distributed and self-organizing network algorithms displaying adaptivity, robustness and scalability. BISON has focused on a number of specific network environments and core functions. Peer-to-peer (P2P) and multi-hop wireless ad hoc (MWAH) networks are the dynamic environments being investigated. The functions are routing, topology management, content search, monitoring, data aggregation and load balancing.

At IDSIA, we have focused on two networks. These are mobile ad hoc networks



From Biology to Dynamic Networks.

(MANETs), which are MWAH networks in which the nodes are mobile and can join or leave the network at any time, and sensor networks, in which nodes are usually not mobile and have specific sensing capabilities. In the case of MANETs, we addressed the issue of the optimization of the routing function to allow the network to cope effectively with the problems raised by mobility and interference. For this purpose we developed AntHocNet, a traffic- and topology-adaptive algorithm with both reactive and proactive components. AntHocNet is designed after ant colonies and their ability to find the shortest paths in distributed and dynamic environments by using a combination of repeated and concurrent path sampling, pheromone laying/following (stigmergic communication), and stochastic decisions.

For sensor networks we focused on the problem of the distributed assignment of node transmission ranges. Here the aim was to establish topologies that can provide full connectivity while minimizing energy consumption, thereby maximizing network lifetime. For sensor networks we developed both an exact cen-

tralized approach and an effective distributed heuristic based on a reaction-diffusion model, which is characteristic of a number of biological processes (eg morphogenetic development). Still in the context of ad hoc networks, but wired ones, we also developed a distributed active monitoring system based on the same ant colony behavior at the heart of AntHocNet.

In P2P networks, all nodes or users can realize bidirectional and symmetric communications. An overlay connecting the peers is established above the IP layer, which provides the underlying communication functionalities. Important issues in P2P networks include strategies for performing general network-wide calculations and searches, as well as building and maintaining overlay topologies. These can facilitate critical operations like content search/publishing and joining/leaving. In BISON we successfully addressed most of these issues.

Cell replication mechanisms provided inspiration for a protocol that builds and maintains random overlay topologies over time, while ideas from cell adhesion

are behind T-Man, a protocol provably able to build a variety of complex structured topologies. The pattern-matching and cell proliferation characteristics of antibodies of the human immune system have provided basic inspiration for an algorithm that effectively performs content searching in unstructured overlays. Diffusion processes and chemotaxis, a process describing cell movement in response to concentration gradients of chemicals, are at the foundations of a system for load balancing in distributed storage networks. A new proactive protocol for the calculation of aggregate functions (eg average load) has been derived from the patterns common to the epidemic spreading of contagious diseases.

In conclusion, the observation of biological processes has provided numerous ideas for the design of a number of fully distributed, adaptive, robust and scalable network algorithms. The experimental results from extensive simulations provide a strong validation of the approaches followed. Performance is usually good, and in some cases the proposed algorithms clearly outperform state-of-the-art algorithms. (This is the case of the algo-

rithms for routing and topology control in wireless networks.) In other cases, such as the protocols for aggregate calculations, excellent empirical performance is also accompanied by pleasing theoretical properties of convergence.

Links:

BISON web site:

<http://www.cs.unibo.it/bison>

IDSIA web site: <http://www.idsia.ch>

Ant Colony Optimization:

<http://iridia.ulb.ac.be/~mdorigo/ACO/ACO.html>

Artificial Immune Systems:

<http://www.dca.fee.unicamp.br/~lnunes/immune.html>

IETF MANET page: <http://www.ietf.org/html.charters/manet-charter.html>

Sensor networks: <http://www.research.rutgers.edu/~mini/sensornetworks.html>

P2P networks: <http://p2p.internet2.edu/>

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Chemical Programming of Self-Organizing Systems

by Jean-Pierre Banâtre, Pascal Fradet and Yann Radenac

Chemical programming relies on the 'chemical metaphor': data are seen as molecules and computations as chemical reactions. This programming paradigm exhibits self-organizing properties and allows the description of autonomic systems in an elegant way.

The Chemical Programming Model

This formalism was proposed to capture the intuition of computation as the global evolution of a freely interacting collection of atomic values. It can be introduced through the chemical reaction metaphor. The unique data structure is the multiset (a set possibly containing identical elements), which can be seen as a chemical solution. A simple program consists of a reaction condition and an action. Execution proceeds by replacing elements that satisfy the reaction condition with the elements specified by the action. The result of such a program is obtained when a stable state is

reached; that is to say, when no more reactions can take place. For example, the computation of the maximum element of a non-empty set can be described as:

replace x, y by x if $x \geq y$

Any couple of elements x and y of the multiset is replaced by x if the condition is fulfilled. This process continues until only the maximum element remains. Note that in this definition, nothing is said about the order of evaluation of the comparisons. If several disjoint pairs of elements satisfy the condition, reactions can be performed in parallel.

Chemical Programming and Self-Organizing Systems

Autonomic computing provides a vision in which systems manage themselves according to some predefined goals. The essence of autonomic computing is self-organization. Like biological systems, autonomic systems maintain and adjust their operation in the face of changing components, workloads, demands and external conditions, such as hardware or software failures, either innocent or malicious. The autonomic system might continually monitor its own use and check for component upgrades. We believe that

chemical programming is well suited to the description of autonomic systems. It captures the intuition of a collection of cooperative components that evolve freely according to some predefined constraints (reaction rules). System self-management arises as a result of interactions between members, in the same way as 'intelligence' emerges from cooperation in colonies of biological agents.

A Self-Organizing Sorting Algorithm

Consider the general problem of a system whose state must satisfy a number of properties but which is submitted to external and uncontrolled changes. This system must constantly reorganize itself to satisfy the properties. Let us illustrate this class of problem by a simple sorting example where the system state is made of pairs (index : value) and the property of interest is that values are well ordered (ie a smaller index means a smaller value). If the environment keeps adding random pairs to the state, the system must reorganize itself after each insertion of an ill-ordered element. The system is represented by a chemical solution "*State = <sort, (i₁ : v₁), ..., (i_n : v_n)>*", consisting of pairs and the following active molecule:

sort = replace (i : x), (j : y)
by (i : y), (j : x) if i < j and x > y

The molecule sort looks for couples of ill-ordered values and swaps them. The solution evolves up to the point where no more reactions are possible: the solution has reached a stable state and the ordering property is satisfied.

Adding new ill-ordered values breaks the 'equilibrium', since the ordering property is violated. However, sort searches continuously for new ill-ordered values and causes reactions so that the state will reach a new stable state.

This very simple example shows how chemical programming can naturally express self-organizing systems. A program is made of a collection of rules (active molecules), which react until a stable state is reached and the corresponding invariant properties satisfied. These rules remain present and are applied (without any external intervention) as soon as the solution becomes unstable again.

Examples of Applications

An autonomic mail system has been described within the chemical framework. Rules ensure that all messages have reached their destination; if it is not the case some reactions occur to reach that state. The system includes rules that ensure other autonomic properties such as self-healing (rules that set and unset emergency servers in case of failures), self-optimization (rules that balance the load between several servers), self-protection (rules that suppress spam or viruses), self-configuration (rules that forward messages to the new address of a user) and so forth.

We have also specified a chemical Distributed Versioning System. In this application, several editors may concurrently edit a document consisting of a set

of files. The editors are distributed over a network and each works on a different version, making modifications to the files and committing them locally. From time to time, two or more editors merge their modifications to propagate them. This system can be easily described with reaction rules to reflect the self-organization of the system. The system is also self-repairing: if an editor loses his local version it can revert to a previous state by synchronizing with one or several other editors.

Future Plans

We are currently studying the application of this model to the coordination of program execution on grids. In a first step, applications are programmed in an abstract manner, essentially describing the chemical coordination between (not necessarily chemical) software components. In a second step, chemical service programs are specifically provided to the run-time system in order to obtain the expected quality of service in terms of efficiency, reliability, security etc.

Link:

J.-P. Banâtre, P. Fradet and Y. Radenac. Higher-Order Chemical Programming Style. In Proceedings of the Workshop on Unconventional Programming Paradigms (UPP'04), LNCS 3566. Springer-Verlag. Also available as preprint at: <http://www.irisa.fr/paris/Biblio/Papers/Banatre/BanFraRad04UPP.pdf>

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A Development Model for Robust Fault-Tolerant Design

by Andy Tyrrell and Hong Sun

Multi-cellular organisms, products of long-term biological evolution, demonstrate strong principles for the design of complex systems. Their nascent processes, including growth, cloning (self-replication) and healing (self-repair and fault-tolerance), are attracting increasing interest from electronic engineers. All of these characteristics are encoded in the information stored in the genome of the fertilized cell (zygote). The process of growth from a single zygote to a mature organism is called development.

Development is controlled by genes, which determine the synthesis of proteins. The activity of genes sets up the complex

interactions between different proteins, between proteins and genes within cells, and hence the interactions between cells.

The development of an embryo is determined by these interactions. Figure 1 shows a representation of the pattern for-

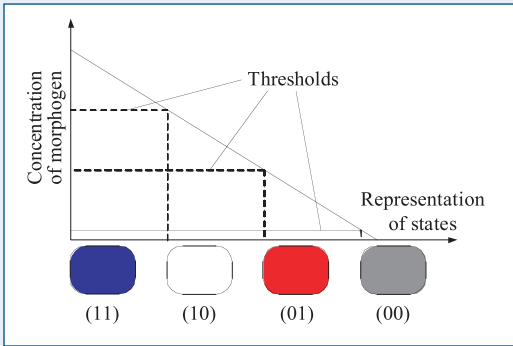


Figure 1: French flag model of pattern formation.

mation of cells controlled by the concentrations of a morphogen. Based on the level of morphogen in each cell, the cells develop into different patterns according to threshold values.

Inspired by natural evolution, Evolvable Hardware (EHW) was developed in the last decade as a new approach to the design of electronic systems. It has demonstrated the ability to perform a wide range of tasks from pattern recognition to adaptive control. A variant of this approach mimics the developmental process from embryo to multi-cellular organism, constructing robust and fault-tolerant circuits.

Motivated by the importance of the interactions in and between cells in biology, this work seeks an approach to increase these interactions, investigating whether this benefits evolution and development. Honeycomb structures, often produced by natural evolution and claimed by architects and economists to be the most efficient structure for covering an area, are used. The concept of a morphogen is employed when judging the state of a cell. The proposed model mimics various cell developmental processes. Although some processes (eg cell movement) are restricted by the fixed hardware architecture, those such as changes in cell state, cell-to-cell signalling, and cell death are modelled.

The cells used in this cellular model are homogenous; they all interpret the same genome and

exhibit the same structure. Each cell has direct access to its six neighbouring cells. No direct access to non-adjacent cells is allowed in the current model. Figure 2 shows the connections between cells. The control unit (CU) in Figure 2 generates the state and chemical of the cell. The state decides what type the cell will be, while the chemical constructs the development environment. The Execution Unit (EU) would perform any functional activities required by the cell (for example logical functions required as part of any arithmetic operations).

This cellular model can be used for the task of pattern formation (the shape of different flags or other shapes) or functional circuits (multiplier or even parity, etc). The difference between pattern formation and functional circuits is that during pattern formation, the fitness of the system is based on whether the states of the cells are in accord with the expected states, the EU not being required. When developing functional circuits, the state generated by the CU is used to control the EU function and the fitness of the system is based on the output of the EU. Here we illustrate an experiment looking at the pattern formation of the French Flag, so only the CU is used.

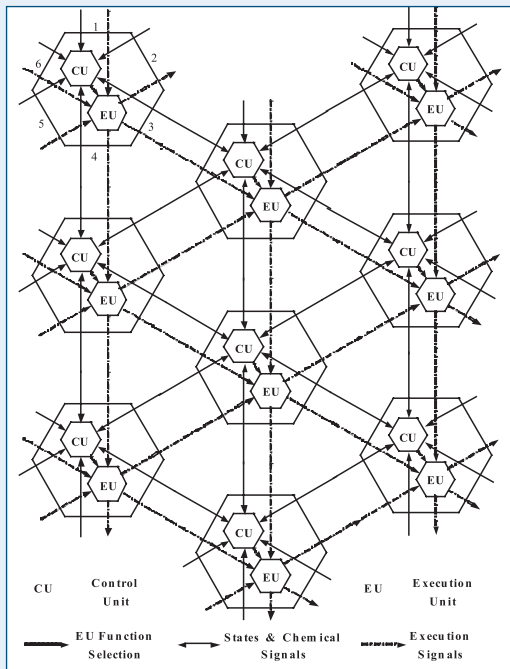


Figure 2: Connections between cells.

The model is defined using the VHDL language, with Xilinx Virtex XCV1000 as its target FPGA. The evolutionary process is designed to be implemented in hardware, and can therefore be considered Intrinsic Evolvable Hardware (IEHW).

Using a process of evolution and developmental growth a French flag pattern can be formed using this hardware. (It should be noted that functional circuits have also been produced using this same technique.) An interesting emergent property of all of these systems is their capacity to recover from different faults.

For example, we can change all red cells into blue, white cells are changed into grey (dead state) and blue cells are switched to red. Hence all the states of cells are wrong and the chemicals are all set to 0. In five steps the system recovered from this fault, and maintained the correct shape thereafter.

In another example, all cells apart from the top left cell are set to dead and their chemicals are set to 0. A correct shape appears in four steps, although this turns into a shape with a fault in another two steps, and finally regains the correct shape in another two steps.

The honeycomb model presented here is part of a larger research project, but this simple example shows its capacity for pattern formation: its ability to develop into a specific shape, maintain that shape and recover to the shape after many kinds of transient faults are injected.

Basic cell processes in embryonic development are imitated. A morphogen is used to mimic the pattern formation process of the embryo. Chemicals are used to build up the environment for development. The interactions between cells are based on the transmission of chemical and state information.

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Emergent Properties of the Human Immune Response to HIV Infection: Results from Multi-Agent Computer Simulations

by Ashley Callaghan

Results obtained from multi-agent computer simulations of the immune response to HIV infection suggest that the emergence of certain properties, or lack thereof, may play a critical role in determining the relative success of the response.

The normal immune response to infection by a virus or bacterium (antigen) is characterized by a complex web of interactions involving numerous cells and molecules of the host's defence system. The response results in the emergence of clones of cells and molecules that together manage to remove the antigen from the body. However, the situation with regards to infection by HIV is different. While the immune system generally manages to bring the viral load (ie the level of HIV) to low levels within

will generally lack the ability to respond to new strains of the virus.

The Need for Models of the Immune Response to HIV

The question now arises as to why we would wish to model this system? The main reason we need models of the immune response to HIV is that a lot of experiments that biologists would like to carry out in order to test hypotheses cannot be performed. The reasons for this include ethical considerations, and the

incorporate many of the key entities that participate in the immune response to HIV infection. The agent-based models we employ for our simulations model each cell as a unique entity with a set of characteristics that, together with clearly specified rules, define its functional behaviour. This approach allows us to incorporate a number of important characteristics, including cell-surface receptors, physical location in the system, affinity for a particular antigen, and so on. The use of advanced techniques such as parallel or distributed computing means we have now reached a stage where it is possible to design simulations incorporating cell population levels that are fast approaching the level found in the human body.

Emergent Properties during the Immune Response

To investigate possible causes that may explain why different individuals show such a wide range of responses to HIV infection, we performed numerous simulations in which different 'patients' were infected with the same quantity of an identical strain of the virus. By different patients, we mean different runs of the simulation, with the only variable being the random seed used to determine the characteristics of the various cells that together make up the immune system. In order to demonstrate the critical role that the emergence of a particular property plays in the relative success of the response, results for three of these hypothetical patients are discussed.

Figure 1a illustrates that the simulations quite accurately capture the viral load dynamics associated with the acute stage of infection as described previously. That is, a rapid rise in viral load is followed by a sharp decline to what is often

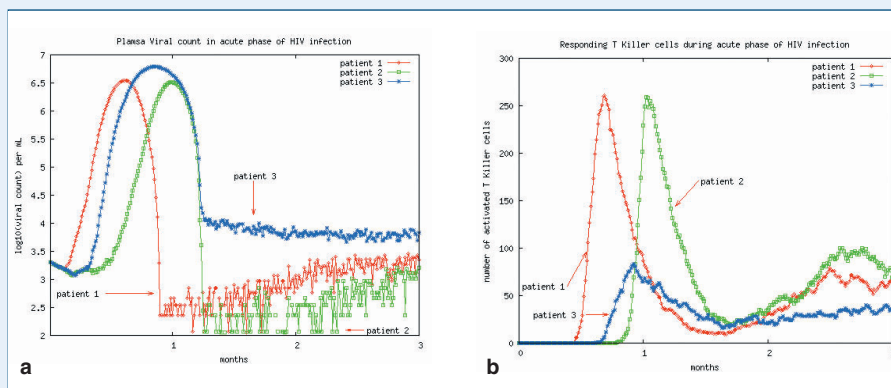


Figure 1: Graphs of viral dynamics and immune response for three hypothetical patients during the acute phase of infection: (a) viral load per mL of plasma; (b) number of activated T Killer cells (CD8) per mL of plasma.

weeks to months of initial infection, HIV is never completely eliminated but instead remains present in low concentrations. The reason HIV manages to escape the immune response is most likely due to two factors – its incredible rate of replication and high rate of mutation. New strains of HIV constantly emerge during infection as a result of the error-prone nature of replication and the rapid turnover of virus in infected individuals. These strains have the potential for immune escape, as the clones of cells that develop against the wild-type virus

fact that biological experiments are very often incredibly expensive and time consuming. If suitable computer or mathematical models existed which could faithfully reproduce what is known from the literature, then it may be possible to carry out certain experiments 'in silico' (ie computer-based simulations), instead of the more usual in vitro and in vivo experiments.

Multi-Agent Computer Simulations

With the computational resources available to us today, we are in a position to construct computational models that

referred to as a 'set point', resulting from the emergence of T Killer cells and HIV neutralizing antibodies.

Figure 1b shows the emergence of activated T Killer cells. These cells attempt to destroy cells infected with HIV before they have a chance to release new virions into the peripheral blood. Comparison of these two figures suggests that the emergence of a sufficiently large T Killer response is critical in bringing viral load to a low level at the set point. In contrast with patients 1 and 2, the T Killer

response that emerges in the case of patient 3 is very poor, with the result that the viral load at the set point is significantly higher than in the other two cases. It has previously been shown that the higher the viral load at the set point, the worse the long-term prognosis with regards the progression of the patient to AIDS. This therefore suggests that the emergence of a sufficient T Killer response during the early stages of infection may play a critical role in determining the length of time before the patient develops full-blown AIDS.

Further Work

As noted previously, one of the most striking features of HIV is its very high rate of mutation. Throughout the course of the infection, mutant strains of the virus are constantly emerging. The relative success of these mutant strains across different patients is a subject that warrants future investigation. **Please contact:**

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Network Emergence in Immune System Shape

by Heather Ruskin, and John Burns

Individual experiences of disease can be extremely diverse. As a result, if targeted treatment of the individual is to be achieved, we need some way of assessing the variables that lead to different outcomes for different people. Visualizing the record of viral attacks in terms of a network of connections that are formed and broken in defence against an attack, can aid in understanding observed effects. This is similar to mapping and redrawing operational outcomes on a larger scale, in order to incorporate necessary or unforeseen changes. Here we describe some of the ideas involved in the formation of connected networks of information at the cellular level, where these provide immune system fingerprints of individual exposure.

Emergent principles of the immune system T-cell repertoire and its self-organization can be simply modelled for a lymphatic compartment, using stochastic cellular automata. The immune system hybrid model incorporates a shape space formalism, permitting each activated effector T-cell clonotype and viral epitope to be represented as nodes of a graph, with edges modelling the affinity or clearance pressure applied to the antigen-presenting cell (APC,) which bears the target epitope. For repeated exposure to infection by heterologous or mutating viruses, a distinct topology of the network space emerges. Properties of the emergent network reflect recent experimental results on cytotoxic T-cell (CTL) activation, apoptosis, cross-reactivity and memory, especially with respect to re-infection.

Biological systems are complex by nature, and the immune system is typical in this respect. In the hybrid model outlined, the real space of the lymphatic compartment – with entities and states

(cell-types) as in Table 1 – exchanges information with the shape space, which models affinity between cell types and clearance pressure. The CTL population grows exponentially in response to APC stimulation, with a rate dependent on the distance between the APC and CTL in shape space. The model permits:

- faithful replication of real-space recirculation dynamics
- representation of T-cell repertoire clonotype distribution and its differentiation, antigenic drift, antigenic shift, immune memory and cross-reactivity
- the evolution of the shape space to be studied through complex network theory.

Notation	Definition
ctl^-	naive recirculating effector precursor
ctl^{++}	proliferating lymphocyte
ctl^{+*}	dead activated lymphocyte (apoptosis)
$ctl^{+@}$	resting memory effector
$ctl^{+@+}$	activated proliferating memory effector
$ctl^{+@!}$	activated memory effector
$ctl^{+!}$	armed activated effector
apc^+	active infected antigen presentation cell
apc^{+*}	dead infected antigen presentation cell

Table 1: Notation and definition of model entity states

Emergent behaviour is thus explicitly exhibited.

The focus here is on two cell- types only, APC and CTL. We omit discussion of the humoral response as well as reference to CD4+ T-cells – their role in facilitating CTL activity is implicitly assumed. Dynamics, governing the affinity between antigen and lymphocyte, arise from the shape space formalism (see Perelson A.S. and Oster G.F. (1979), Theoretical Studies of Clonal Selection: Minimal Antibody Repertoire Size and Reliability of Self-Non-Self Discrimination. *J. Theor. Biol.*, 81 (4):645-70). Each unique antigen epitope and CTL clone is represented as a point within the two-dimensional space of given size. Surrounding each CTL clone is a disc of radius r . Any antigen epitope located within the disc is subjected to a clearance pressure with a force inversely proportional to the separation distance (see Burns J. and Ruskin H.J. (2004) Diversity Emergence and Dynamics during Primary Immune

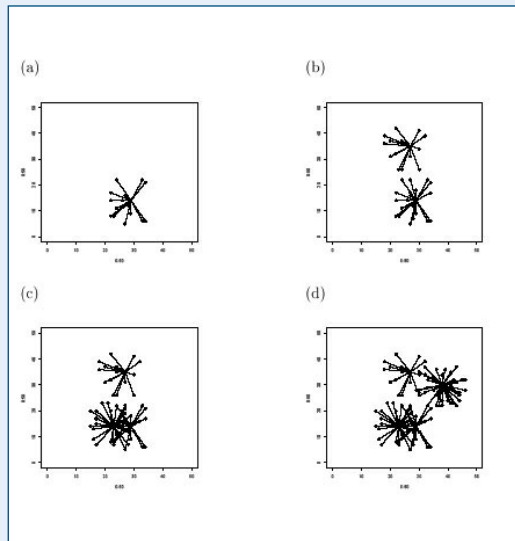


Figure 1: Development of 4-epitope network. Only CTL clonotypes are shown. Centres and edges = immunogenic epitopes and stimulated CTL respectively. By (c) there is a pool of memory CTL clonotypes, some close enough in shape space to exert clearance pressure against the heterologous virus, (non-leaf nodes deg (2)). By (d), suppression of final infection sees cross-reactive contribution of memory cells, specific to a virus, thus resulting in a network connection.

homologous viruses, with cross-reactive epitopes.

Early and protective immunity can be mediated by memory T-cells generated by previous heterologous infection (represented graphically by nodes with degree > 2). Cluster linkage illustrates conditions by which immunity to one virus can reduce the effects of challenge by another (see Figure 1). Damage to or suppression of critical cross-reactive ‘a’-nodes has significantly greater impact than damage to leaf or ‘b’-nodes. Different disease outcomes to identical infection strains can be explained in terms of density and distribution of a-nodes. The degree of protection from cross-reacting memory cells depends on the distance between the memory T-cell clonotype and immunogenic epitope, with optimal immunity for re-infection by the same antigenic epitope. Results show increasingly effective clearance dynamics as the memory pool increases and each T-cell clone has a finite chance of becoming a long-lived memory cell.

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Response: A Shape Space, Physical Space Model: Theor. in Biosci., 123(2):183-194). A network model of shape space emerges naturally from the real-space model, with each immunogenic epitope e_k and activated CTL clonotype c_j represented by a node in the space. Clearance pressure applied between two nodes forms a directed edge between them, with a weight dependent on the affinity. After initial infection, most c_j undergo programmed apoptosis (a crucial regulator of immune system homeostasis), which corresponds to edge deletion. However, recruitment to the

memory pool consumes a given percentage of activated CTL, so nodes remain active in shape space, preserving edge connections to stimulatory epitopes.

Recent work indicates that effector CTL memory cells can recognise epitopes of unrelated viruses, so that heterologous viruses (derived from a separate genetic source) may be a key factor in influencing the hierarchy of CD8+ T-cell responses and the shape of memory T-cell pools. Shape space can be used to model both homogeneous viruses with conserved and mutated epitopes, and

Agent-Based Modelling of Viral Infection

by Dimitri Perrin

The three phases of the macroscopic evolution of the HIV infection are well known, but it is still difficult to understand how the cellular-level interactions come together to create this characteristic pattern and, in particular, why there are such differences in individual responses. An ‘agent-based’ approach is chosen as a means of inferring high-level behaviour from a small set of interaction rules at the cellular level. Here the emphasis is on cell mobility and viral mutations.

One of the most characteristic aspects of the HIV infection is its evolution: in the initial short acute phase the original viral strains are destroyed, in the second year-long latency period, the number of strains slowly increases and, in the final phase, Acquired ImmunoDeficiency Syndrome (AIDS) develops when the immune system is no longer able to cope with the multiplying strains and is overcome. The principal aim of this work, based at Dublin City University, is to try to understand why the range of experi-

ence with respect to HIV infection is so diverse. In particular, the work aims to address questions relating to variation in the length of the individual latency period. This may be very long (for relatively low success of antipathetic mutation) in one individual, compared to another with much higher mutation levels.

The indications are that the observed variation lies in the priming and initial level of fitness of the immune response

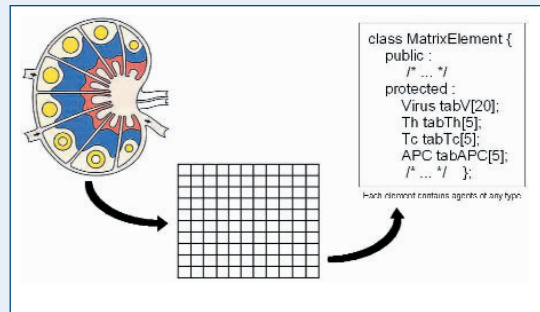
of the individual, together with the various factors that influence this. If such ‘priming patterns’ can be recognized or even predicted, then in the long term we may have a way of ‘typing’ an individual and targeting intervention appropriately. Unfortunately, understanding how the immune system is primed by experience of antigenic invasion and diversity is non-trivial. The challenge is to determine what assumptions can be made about the nature of the experience, and then modelled, tested against clinical

data and hence argued plausibly. The aim is to understand how the cell interactions lead to the observed endpoints. What exactly is involved in antigenic diversity? How variable is the mutation rate and the viral load? What is the importance of cell mobility and how realistic is this in terms of cross-infection and subsystem involvement? How important then is the cross-reactivity?

The immune response is dynamic and includes growth and replenishment of cells and in-built adaptability, through mutation of its defences to meet new threats. It also includes aspects of cell mobility, which may be captured by means of defining the movement and affinity of cell-types in a defined spatial framework. In particular, this will enable us to study the variation in viral load and the way in which the host response may lead to degradation of protection.

To investigate these questions, an 'agent-based' approach is chosen as a means of inferring high-level behaviour from a small set of interaction rules at the cellular level. Such behaviour cannot be extracted analytically from the set of rules, but emerges as a result of stochastic events, which play an important part in the immune response.

The initial model consists of agents (or functional units) with designated properties that mimic the operation of a single



The lymph node (adapted from N. Levy, Pathology of lymph nodes, 1996) is modelled as a matrix in which each element is a physical neighbourhood and can contain several agents of each type.

lymph node (as a test case). This prototype, however, includes all known interactions contributing to cell-mediated immunity and the local evolution of the virions. The antibody-mediated response has not been considered initially, because the cell-mediated arm plays a dominant role in repelling attack. The agents implemented represent Th (helper) and Tc (cytotoxic) lymphocytes, Antigen Presenting Cells and virions. They inherit from a common C++ class designed to deal with features such as mobility. Each class then implements through attributes and methods the specific properties of each cell type, such as the activation of a Tc cell by a Th cell. The lymph node is modelled as a matrix in which each element is a physical neighbourhood able to contain various agents of each type.

The next step is to increase of the number of lymph nodes. This extension involves millions of agents and requires major computational effort, so that parallelization methods are inevitable. The

use of these methods is a natural consequence and advantage of the multi-agent approach. A human body contains hundreds of lymph nodes. The aim here is to extend the size and complexity of the systems that can be modelled to something approaching reality.

The representation of the innate response as a common background and the adaptive part as a characterized set of features will be the next step. This will allow the development of a large system to be studied over a longer period, in order to focus on disease progression endpoints and intervention effects.

The author would like to thank the Irish Research Council for Science, Engineering and Technology for the funding made available through the Embark Initiative.

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The 'Decent' Project: Decentralized Metaheuristics

by Enrique Alba and Martin Middendorf

The project 'Decent' (Decentralized Metaheuristics) is developing new swarm-based metaheuristics in which a decentralized design leads to emergent phenomena. These are not only important for solving complex problems, but are suitable for parallel execution in computing grids and multi-task hardware platforms.

Metaheuristics, such as evolutionary algorithms (EA), ant colony optimization (ACO), simulated annealing (SA) and particle swarm optimization (PSO), are methods that can be applied successfully to almost all optimization problems. For many hard tasks in a huge variety of areas, these algorithms are consid-

ered to be the state-of-the-art methods; these areas include engineering applications, bioinformatics, telecommunications, logistics and business.

Due to their practical importance and the need to solve large real-world instances of hard problems, parallel algorithms

have been proposed for most metaheuristics. However, most approaches do not utilize the full potential of parallel execution because of their synchronicity and execution on clusters of homogeneous machines. All this makes it difficult to apply them to interesting parallel systems such as dynamically reconfig-

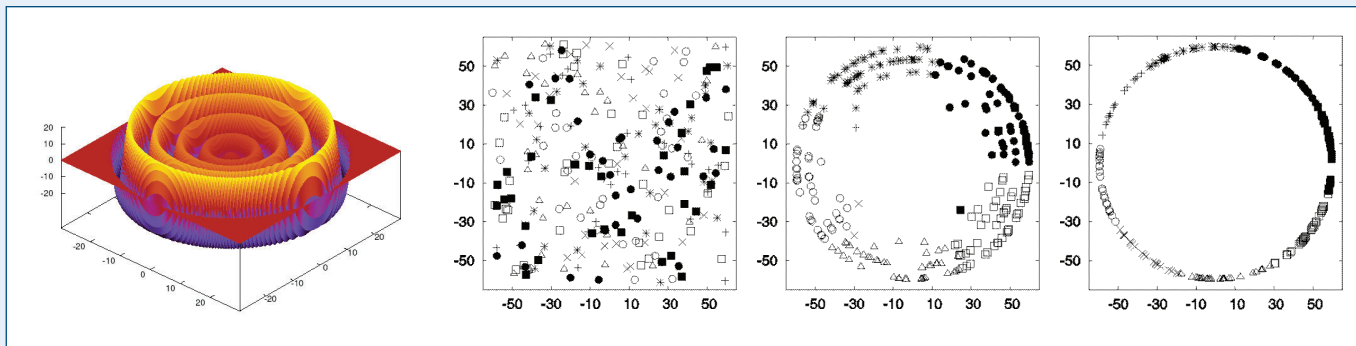


Figure 1: Test function (left) and emergent behaviour of the algorithm; swarm particles after 0, 50 and 400 iterations.

urable hardware (eg FPGAs) and large heterogeneous networks (computational grids).

In the ‘Decent’ project, strictly decentralized versions of metaheuristics that do not suffer from the restrictions of standard parallel/distributed metaheuristics are developed. ‘Decent’ is a two-year joint project between researchers from the University of Málaga (Spain) and the University of Leipzig (Germany). The project is funded by MECD (Ministerio de Educación y Ciencia, Spain) and DAAD (German Academic Exchange Service) within the ‘Spain-Germany Integrated Actions’ framework (HA2004-0008). The main focus of the project is on decentralized algorithms that are suitable for dynamically changing heterogeneous networks, as mobile ad hoc (and sensor) networks and dynamically reconfigurable computing systems. One main goal is to investigate the emergent properties of such decentralized swarm-based algorithms, not found in the separate behaviour of their components. This is expected to have a significant impact both in the field of advanced algorithms and in applications. This is particularly the case for complex problems arising in telecommunications (routing, coding, broadcasting etc) and bioinformatics

(DNA fragment assembly, protein structure etc).

In the first year of the project, a decentralized clustering algorithm that can cluster data packets in networks was designed and applied to Particle Swarm Optimization (PSO). PSO is a metaheuristic inspired by bird flocking behaviour. A PSO algorithm maintains a swarm of particles, which move through the search space in the search for an optimal value. The movement of a particle is influenced by its velocity and the positions where good solutions have already been found, either by the particle itself or by other particles in the swarm. Figure 1 shows a test function that is to be minimized. It can be seen that the clustering helps the PSO to explore different areas containing minimum function values.

Another example of emergent behaviour appears in cellular Genetic Algorithms (cGA). This is a kind of population-based technique in which tentative solutions are evolved on a given topological structure, eg a toroidal 2D mesh (see Figure 2). Each individual in such a population has a fitness (quality of a problem solution) that is iteratively improved by applying operators to the set formed by one individual and its neighbours (much in the manner of traditional GAs, but on overlapped small neighbourhoods

defined in the population, eg having five individuals).

Figure 2 illustrates the evolution of a grid of individuals that separately evolve to solve the same problem. Neighbourhoods interact by means of implicit information exchanges achieved by the application of recombination of their shared individuals. Stochastic mutation of the individual contents is also performed, and new individuals are kept at each grid position if they are better than the existing ones. Such decentralized behaviour means that diversity is preserved in the solution space. It also allows a graceful convergence to an optimal solution that would be hard or even impossible to locate with other algorithms. The work in progress includes self-organization of the emergent behaviour and parallelization in clusters and grids.

Most of this work is related to the Spanish TRACER project and to the European EMBIO project.

Links:
<http://neo.lcc.uma.es>
 EMBIO project <http://www-embio.ch.cam.ac.uk>
 TRACER project: <http://tracer.lcc.uma.es>

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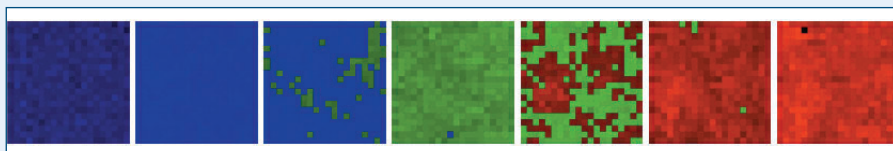


Figure 2: Snapshots for a cellular Genetic Algorithm (cGA) every fifty iterations until a problem solution is located (black point in rightmost figure). The brighter an individual is coloured the higher is its fitness (black means a solution has been found); green individuals are within 80% of the optimum value and red ones are within 90%.

Evolutionary Methods make New Effective Laser Shapes

by Thomas Bäck and Joost N. Kok

Controlling the behaviour of atoms and molecules by very short laser pulses using so-called femtosecond lasers is a very active and challenging research field. In a collaboration between the Leiden Institute of Advanced Computer Science (LIACS) and the Institute for Atomic and Molecular Physics, Amsterdam (AMOLF), evolutionary algorithms are used to optimize the shape of such laser pulses, based on a reformulation of the task as a high-dimensional, nonlinear optimization problem. These optimization methods, gleaned from the model of organic evolution, turn out to be well suited for tackling this challenging task.

Traditionally, the advancement of physical understanding through experimental research involves the definition of controlled experiments in which a problem of interest is studied as a function of one or more relevant experimental parameters. The outcome of the experiment then provides insight into the specific role of these parameters. This approach dates back to the days of Galileo. In a famous series of experiments, he measured how far a ball rolls down a gradient as a function of the parameter time, and concluded that the distance travelled by the ball is proportional to the square of the time. This approach has led to an enormous wealth of accumulated knowledge. However, it fails when the number of parameters relevant to the problem of interest becomes very large. These days more and more of these situations are encountered.

In problems in physics that depend on a large number of parameters, great advances can be made using a new approach based on evolutionary algorithms. The large number of parameters limits the usefulness of experiments where only some of these parameters are varied in a prescribed manner. An evolutionary approach is a viable alternative in many of these situations. In this approach the system of interest is studied within a closed loop strategy, where in each iteration the set of system parameters is modified to some extent by means of specialized mutation and recombination operators. After doing an actual experiment on the system with these parameters, the best performing values for achieving a given objective (also called fitness in evolutionary algorithms) are selected for the next round.

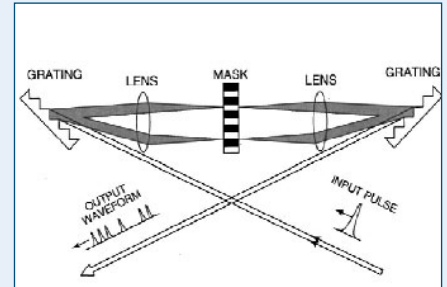


Figure 1: The instrumental set-up for the laser pulse shaping experiment. The mask is controlled by a large number of continuous parameters, which affect the final form of the pulse in a highly nonlinear way.

The key advantage of this iterative optimization approach is that one does not need to know a priori the details of the working mechanism of the complex system. Instead, the goal is to learn about the underlying physics by interpreting the sets of parameters produced by the evolutionary algorithm. This is in contrast to performing experiments with controlled variations (ie knowledge-based or trial-and-error-based variations by human experts) of these parameters. Because of the generic nature of the evolutionary approach, this methodology can be applied to a wide variety of different situations.

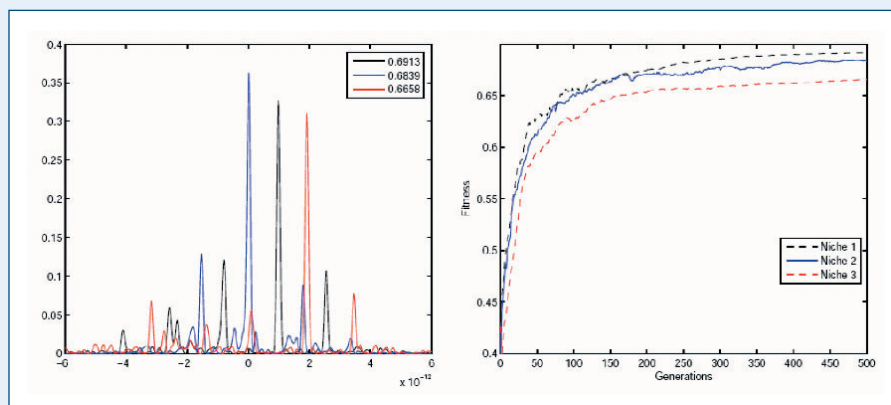


Figure 2: Three different pulse shapes which have been obtained by evolutionary algorithms (left), and the corresponding course of the optimization process plotted as quality of the pulses over time (right). It is clear that, due to the niching technique employed, very different pulse shapes have been found which are nevertheless very similar in their final quality, thus confirming the high complexity of the underlying optimization problem.

For as long as efficient optical sources have been available, scientists have tried to use optical means to control the behaviour of atoms and molecules. Specifically, with the availability of easy-to-use tunable lasers, numerous efforts have been undertaken to control the dynamics (dissociation, ionization, reactivity) of chemically and biologically relevant species. In a joint Dutch 'Foundation for Fundamental Research on Matter' (FOM) project between LIACS (Professors Bäck and Kok) and AMOLF in Amsterdam (Professors Vrakking, Herek, Muller and Tans), interesting results have been obtained in the field of femtosecond laser pulse shaping using evolutionary algorithms.

There is currently great interest in the atomic and molecular physics community in aligning molecules with laser pulses, since dealing with an aligned sample of molecules simplifies the interpretation of experimental data. To control the motion of atoms or molecules by irradiating them with laser light, one has to provide laser pulses with durations on the same time scale as the motion of the particles. The outline of an experimental setup for such an experiment is illustrated in Figure 1. By applying a self-learning loop using an evolutionary algorithm, the interaction between the system under study and the laser field

can be steered, and optimal laser pulse shapes for a given optimization target can be found. The target function is the alignment of an ensemble of molecules after interaction with a shaped laser pulse. Using so-called niching methods, which make sure that an evolutionary algorithm yields several alternative solutions, new effective laser pulse shapes were detected.

Recent results (see Figure 2 for pulse shapes and the corresponding course of evolution) have shown how fruitful the cooperation between researchers from Evolutionary Algorithms and Molecular

Physics can be, and clearly demonstrate advances in both fields (namely, optimized pulse shapes and new concepts in evolutionary algorithms). Moreover, as the project started just one year ago, a variety of additional results over the course of this collaboration are expected.

Link:
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Neural Net Modelling in Financial Engineering of Options

by Jerome Healy, Longchuan Xu, Maurice Dixon, Fang Fang Cai, Brian Read and Brian Eales

Financial options play a key role in the risk management carried out by financial institutions. As a consequence, their pricing and hedging against adverse market movement is a major challenge for loss avoidance. Although standard options are regulated by the exchanges, exotic options are traded over-the-counter. Neural networks provide a powerful way of deriving models from traded data that are free from most financial modelling assumptions.

A standard call (put) option gives the holder the right but not the duty to buy (sell) an asset on or before a future date at a price specified now. This enables the holder, for a premium, to hedge against adverse asset price changes while benefiting from favourable movements.

The Financial Market Modelling project aims at developing a computational framework with techniques appropriate to accurately predicting option prices from exchange data, and to hedging their movement against adverse movements. This would enable issuers of options to buy and sell financial instruments to change their exposure as the market moves.

The research is grounded in the underlying data-mining program of the Business and Information Technology Department of CCLRC. Recently a project grant was obtained from HEFCE by London Metropolitan University, Londonmet, to

establish a Financial Modelling Research Base at Moorgate in the City.

There is now an abundance of high- and low-frequency data available from various exchanges. Analytic models have tended to assume an underlying log-normal pricing distribution following Black-Scholes-Merton. Numerical models free from this and other constraints can be extracted from traded data.

The aim of the project is to provide a systematic framework for the generation of numerical models and predictions/forecasts from option market data. This will be done by combining established modelling approaches with diagnostic techniques from econometrics.

The development framework was CRISP-DM (CRoss Industry Standard Process for Data Mining). It was specialized to option market applications. Neural nets were deployed to provide regression models that are twice differ-

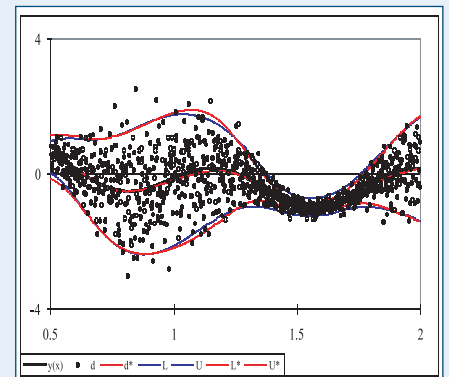


Figure 1: Prediction Bands for Synthetic Example — $y(x)$ is the true regression for a benchmark synthetic model; d represents the target data points generated by adding a known noise function to it. d^* is the estimate of the target. L and U are the true upper and lower prediction intervals while L^* and U^* are the approximate prediction intervals obtained from the prediction for the variance (squared error).

entiable; also they are used to provide self-error estimates. Linear regression and Monte Carlo simulations supported the investigation. Standard commercial database, spreadsheet, and data-brushing tools were linked to a data-mining work-

bench, SPSS Clementine and to the econometric tool eViews from Quantitative Micro Software.

Initial work concentrated on demonstrating high accuracy ($R^2 > 0.99$), but avoiding over-fitting, using neural nets for pricing standard options with fixed expiry dates from daily data. These had been traded as ESX options on the London International Financial Futures and Options Exchange, LIFFE.

An important advance was the development of a practical method for obtaining, for unknown targets, confidence of prediction intervals. It uses the capacity of a neural net to model the joint probability distribution of a function value and point squared error. The method is robust to variable error bars. Its application to a synthetic benchmark problem is shown in Figure 1, where there is good signal recovery from very noisy data. Since second derivatives of neural nets can be determined, it is possible to obtain an important probability distribution, the risk neutral density (RND). This means that that forward expectation of an asset price can be used to aid in setting a measure of value-at-risk. The extension to

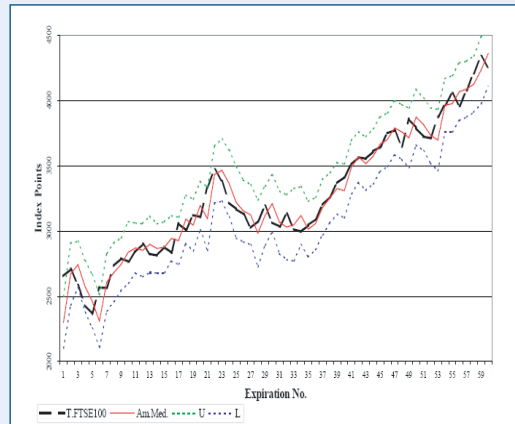


Figure 2 SEI Put Option RNDs - One-Month Forecast of FTSE 100 Level. One-month forecasts of the FTSE 100 closing price from the extension of RNDs to SEI (American) put options that can be exercised early. The forecast values (red line) are the medians of the RNDs. The heavy black dashed line is the FTSE 100 closing price one month (17/18 trading days) later. The dotted green and blue lines are ± 2 standard deviation ($\approx 95.46\%$) confidence intervals. The true values lie within the confidence band in all cases.

early exercise put options, SEI, is shown in Figure 2.

Future work will include over-the-counter (OTC) options, which are priced on the basis of a direct contract between option buyer and seller. These are not exchange regulated and the prices are not publicly available. In addition, some OTC options have a discontinuity where the value changes to/from zero if the asset touches a value called the barrier. Barrier options pose specific problems as hedging depends on the value of the gradients close to a discontinuity.

The approaches developed here have been applied to an environmental appli-

cation in the recent ERCIM-managed project, TELEMAT. The visualization approaches applied in TELEMAT have been shown to be very helpful for the financial data inspection.

Link:

<http://epubs.cclrc.ac.uk/>

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Self-Optimization in a Next-Generation Urban Traffic Control Environment

by Raymond Cunningham, Jim Dowling, Anthony Harrington, Vinny Reynolds, René Meier and Vinny Cahill

The Urban Traffic Control Next Generation (UTC-NG) project tackles the problem of global optimization in next-generation UTC systems by using sensor data to drive a fully decentralized optimization algorithm.

Current approaches to Urban Traffic Control (UTC) typically take hierarchical and/or centralized approaches to the global optimization of traffic flow in an urban environment, often with limited success. By exploiting the increasing amounts of available sensor data (eg from inductive loops, traffic cameras, on-board GPS systems etc), next-generation UTC system designers possess a unique opportunity to address the problem of global optimization of traffic flows.

Recent advances in sensor technology have made online vehicle and traffic flow detection possible. This in turn has enabled adaptive traffic control systems, capable of online generation and implementation of signal-timing parameters. Adaptive control systems are widely deployed throughout the world.

However, the adaptive traffic-control systems that are currently deployed are hampered by the lack of an explicit coordi-

ination model for traffic-light collaboration, and are typically reliant on previously specified models of the environment that require domain expertise to construct. These models are typically used as an input to both sensor data interpretation and strategy evaluation, and may often be too generic to adequately reflect highly dynamic local conditions.

These systems have a limited rate of adaptivity and are designed to respond to grad-

ual rather than rapid changes in traffic conditions. They employ centralized or hierarchical data processing and control algorithms that do not reflect the localized nature of fluctuations in traffic flow.

Collaborating Traffic Lights

An alternative approach to the one pursued by existing UTC systems is to allow the controller/agent of the set of traffic lights at a junction to act autonomously, deciding on the appropriate phase for the junction. The actions available to such an agent are similar to the those available to a traffic manager in a centralized/hierarchical UTC system (ie remaining in the current phase or changing to another available phase).

In a similar manner to existing centralized/hierarchical UTC systems, the agent would monitor the level of congestion at the junction under its control based on available sensor data and use this information to decide which action to take. Over time, the agent learns the appropriate action to take given the current level of congestion. However, if the agent at a junction simply optimizes its behaviour using only local congestion information at that junction, this may result in locally optimal performance but also in suboptimal overall system performance.

In order to achieve optimal system-wide performance, the set of agents at traffic light junctions in the UTC system should communicate their current status to agents at neighbouring upstream and down-

stream junctions. These can then utilize this information when choosing the appropriate action to take. By operating in this completely decentralized way, the UTC system obviously becomes self managing and can, less obviously, be designed to optimize the global flow of vehicles through the system. The technique used to achieve this decentralized optimization through coordination/collaboration is called Collaborative Reinforcement Learning (CRL).

Distributed Optimization

CRL is a decentralized approach to establishing and maintaining system-wide properties in distributed systems. CRL extends Reinforcement Learning (RL) by allowing individual agents to interact with neighbouring agents by exchanging information related to the particular system-wide optimization problem being solved. The goal of CRL is to enable agents to produce collective behaviour that establishes and maintains the desired system-wide property.

Optimizing the global flow of traffic in a UTC system can be considered as a single system-wide problem. This can be decomposed into a collection of discrete optimization problems, one at each traffic light junction in the UTC system.

Since each traffic light agent has a sub-problem that is unique to that agent, a traffic light agent cannot delegate the solution of this problem to one of its neighbours. Rather, the agent must

attempt to solve its problem locally by devising an appropriate policy. However, as the solution to the problem depends on local traffic conditions that vary over time, the traffic light must continually attempt to estimate/learn the optimal policy for the junction under its control.

Status

In a similar approach, UTC-CRL is taking an experimental approach to validating the appropriateness of CRL in a large-scale UTC setting. In particular, an objective of the UTC-CRL experimental approach is to verify that a consensus can emerge between collaborating traffic light agents, and that this consensus allows optimal traffic flow in the large-scale setting. The envisioned setting for this work corresponds to the Dublin city area, which consists of 248 traffic light junctions, over 750 non-traffic light junctions, and over 3000 links between these junctions.

The UTC-NG project is supported by the TRIP project, a multi-disciplinary research centre funded under the Programme for Research in Third-Level Institutions (PRTLTI), administered by the Higher Education Authority.

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Self-Organized Routing in Mobile Ad Hoc Networks using SAMPLE

by Jim Dowling and Stefan Weber

In the SAMPLE project, we are investigating decentralized collaborative learning techniques to develop a routing protocol for Mobile Ad Hoc Networks, where routing agents collectively learn to exploit stable routing paths in the network environment. This approach to routing lends itself to large-scale ubiquitous computing scenarios, in which large numbers of ubiquitous mobile devices are intermixed with static infrastructure networks.

Mobile Ad Hoc Networks (MANETs) are a promising area of application for emergent computing techniques. Traditional distributed-systems tech-

niques based on strong consensus and global knowledge are breaking down due to the decentralization and dynamism inherent in these environ-

ments. Current approaches to routing in these environments see individual MANETs as separate from existing infrastructure, and view the network

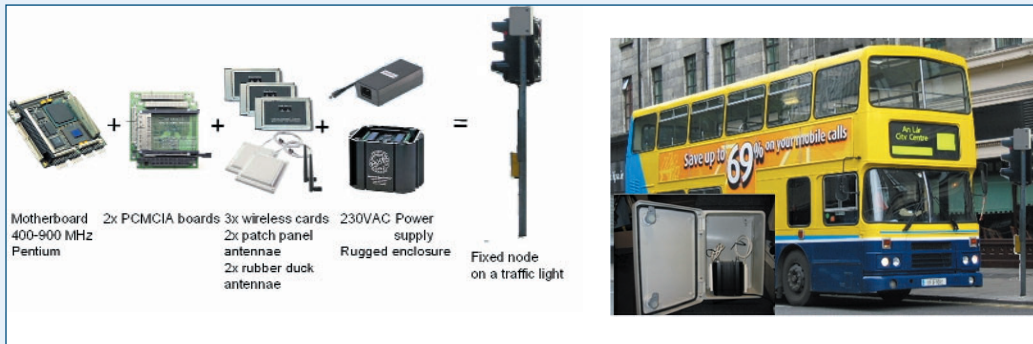


Figure 1: Components of a wireless node and the installation of these nodes in the WAND testbed.

nodes as homogeneous. However, wireless infrastructures are increasingly considered to be a community service (also called muni-wireless networks) that should be provided by local authorities. Mobile devices in these environments exhibit various levels of processing power, mobility and connectivity, but existing approaches do not consider these characteristics. In the SAMPLE project, we are developing a routing protocol for metropolitan area MANETs. In these networks, mobile nodes collectively learn and self-organize to exploit any fixed or temporary network infrastructure in the environment.

The SAMPLE project is concerned with developing a MANET routing protocol for WiFi-enabled computing devices such as laptops, smart mobile phones and handheld devices. In MANET routing protocols, computing devices, also called nodes, act as both consumers and providers of the routing services in the network. In particular, we have been investigating how nodes can collectively determine the stability and quality of network links in the system. This ability is particularly beneficial in the presence of a wireless infrastructure, as nodes learn to route over the higher-performance stable paths in the infrastructure to access popular services such as e-mail and the Web.

The design of the SAMPLE protocol is based on collaborative reinforcement learning (CRL), an unsupervised learning algorithm that enables groups of reinforcement learning agents to solve system online optimization problems. CRL provides feedback models that map changes in an agent's environment and its neighbours onto internal changes in the agent's policy, using distributed model-based reinforcement learning.

Positive and negative feedback are the key mechanisms that adapt an agent's behaviour to both its neighbours and a changing environment. In SAMPLE, routing agents use CRL to explore their local environment by executing routing actions, and provide one another with feedback on the state of routes and network links. Using CRL, agents adapt their behaviour in a changing environment to meet system optimization goals while using only local state information.

SAMPLE has been implemented in the NS-2 simulator, and the results have been very encouraging. Simulations show how feedback in the selection of links by routing agents enables them to self-organize in varying network conditions and properties, resulting in the optimization of network throughput. In experiments, emergent properties such as traffic flows that exploit stable routes and re-route around areas of wireless interference or congestion have been demonstrated. As such, SAMPLE is an example of a complex adaptive distributed system.

We are now moving to the deployment phase of the project, in which the protocol will be tested on a real-world testbed. The Wireless Area Network for Dublin (WAND), which we have deployed in the centre of Dublin city, is a testbed infrastructure covering a 1.5km route from Trinity College to Christchurch Cathedral. It allows experimentation on both protocols and applications for MANETs in a metropolitan area. An initial implementation of the protocol has been developed for Linux and experiments will establish its performance in a real-world wireless network.

As part of the project, we are also investigating the use of SAMPLE for carrying

different types of traffic in MANETs, such as data and voice traffic. The development of a protocol to carry voice traffic over muni-wireless networks would allow the provision of free voice calls, something currently only available on the Internet. However, to achieve this goal, self-organized routing techniques will be required for dynamic networks where topology, resources and node availability are subject to frequent and unpredictable change.

Our research is conducted as part of the CARMEN project, which is funded until 2006 by the Higher Education Authority (HEA) of Ireland.

Links:

SAMPLE website:

<http://www.dsg.cs.tcd.ie/sites/SAMPLE.html>

WAND website:

<http://www.dsg.cs.tcd.ie/sites/WAND.html>

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XMapper: a Service-Oriented Utility for XML Schema Transformation

by Manuel Llavador and José H. Canós

A typical case of low-level interoperability, particularly frequent in the Digital Libraries world, is the federation of collections via metadata conversion. Roughly speaking, a federation consists of a number of repositories, each with its own format, which agree on a common format for metadata exchange. Any metadata record, must then be transformed into the common format before it is sent as the result of a request. In this note, we report on a solution to the metadata conversion problem based on semantic mappings. Although it was developed to federate collections in a specific project, XMapper is domain-independent and can be used in any context where an XML schema transformation is required.

Making distributed and heterogeneous systems interoperate has been a challenge for researchers and practitioners over the last decade. The complexity of the problem has led to solutions with increasing levels of sophistication, depending on the requirements imposed by the domains of the application. Different forms of middleware represent the most general solution for achieving full interoperability, but in some cases simpler solutions can be used. This is particularly the case when the requirement for interoperability originates from the heterogeneity of (meta)data formats, as often happens in the Digital Libraries world.

Such a problem arose during the development of BibShare, an environment for bibliography management, a project funded by Microsoft Research Cambridge, that allows users to collect bibliographic references, insert citations into documents and automatically generate a document's bibliography. Unlike former tools, BibShare works with a variety of word-processing systems, and permits references to be inserted not only from personal citation collections, but also from bibliography servers available on the Internet, such as DBLP. As might be expected, each collection has its own metadata format(s). In order to unify the result sets of federated searches and return these data to the user, each record retrieved must be converted to a common format. We call this the Bibshare Bibliographic Format (BBF).

Given that XML is used to exchange data, the natural solution to the problem

is to use XSL transformations between records. For a collection to be added to the BibShare Federation, the owner of the collection must create an XSL template that transforms the records to the BBF. However, writing an XSL template is not a trivial task, and any tool supporting template generation would represent a significant improvement to the federation process.

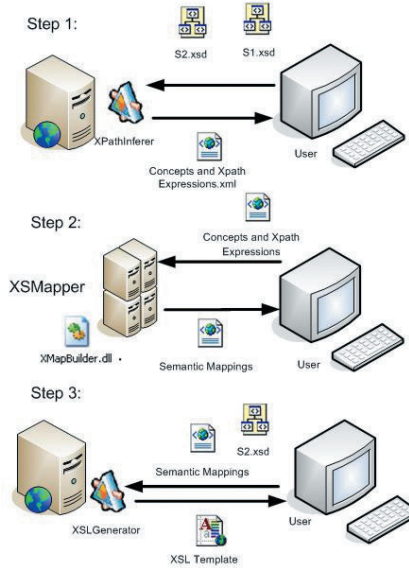
Since the problem of document transformation goes beyond the scope of Bibshare, we developed a general solution to the problem. In its most general version, this be stated as follows: given two XML Schemas S1 and S2 that represent respectively the source and target formats of a transformation, obtain as automatically as possible the XSL template that transforms S1-valid documents into S2-valid documents.

XML Semantic Mapper (XMapper) solves the problem based on the definition of semantic mappings between source and target schemas, following three steps (see figure):

1. Extraction of the concepts that are used both in source and target schemas. A concept is a term used to name different elements in an XML document. For instance, the concept 'author' is used to denote the elements representing the authors of books and articles; this means that there will be different elements 'book/author' and 'article/author', which may be translated to the same element in a target schema (eg following the LaTeX model, an element 'bibitem/author').

This step is performed automatically by the XPathInferer Web service. This service not only finds the concepts, but also their location within documents in the form of XPATH expressions. This is very important because location in the document can be a key property during the conversion process.

2. Definition of the semantic mappings between the elements of S1 and S2. This step cannot be performed automatically, unless some ontology relating the concepts in both schemas can be used to infer them. XSMapper provides a friendly user interface for defining three kinds of mappings, namely direct, function-based and constant. Direct mappings are used to link one or more concepts of the source schema to one or more concepts of the target schema that are semantically equivalent (eg the 'author' presented above). Function-based mappings are defined in cases where it may be necessary to apply some functions to the source concepts in order to get the equivalent target elements (for instance, splitting one concept like 'author' into two concepts 'first name' and 'surname'). As we are using XSLT to transform documents, we can use the set of functions pro-



XSL template generation workflow.

vided by XPath and XSLT to define our function-based semantic mappings. Finally, the constant mappings are used when we want to assign a constant value to a target concept.

3. Generation of the XSL template. This task is performed automatically by the XSLGenerator Web service. An XSL template has two kinds of elements: structural elements and value-selection elements. The former build the

resulting XML tree (composed of elements and their attributes), instantiating the target schema. The latter inserts the source schema values in the resulting XML text following the semantic mappings defined in step 2.

Notice that most of the components of XSMapper are available as XML Web services, and can be used at the URLs listed below. We are working on a variety of improvements to the tool, with special emphasis on looking for ways to automate the definition of the semantic mappings that would make XML conversion a fully automated task.

Links:

Bibshare: <http://www.bibshare.org>

XSMapper:

<http://bibshare.dsic.upv.es/XSMapper.exe>

XPathInferer Web service:

<http://bibshare.org/XPPathInferer/XPIWS.asmx>

XSLGenerator Web service:

<http://bibshare.org/XSLGenerator/XSLGeneratorWS.asmx>

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Analysis and Modelling of Genomic Data

by Anna Tonazzini, Francesco Bonchi, Stefania Gnesi, Ercan Kuruoglu and Sergio Bottini

At ISTI-CNR, Pisa, researchers from different areas of computer science are studying an integrated and interdisciplinary approach to various problems in Computational Biology and Bioinformatics.

The achievements of the Human Genome Project and the rapid development of post-genomic technology have dramatically increased the importance of genomics and genetics in disease analysis and diagnosis, novel drug and therapy discovery, and early detection or even prediction of disease. The aim is to improve healthcare strategies and, ultimately, the quality of life of the individual. Due to the enormous flow of heterogeneous biological data that is being made available, powerful tools for storage and retrieval, processing, analysis and modelling are becoming

increasingly crucial in order to be able to extract useful knowledge from this data.

Bioinformatics exploits modern computing and communication technology, and is stimulating research that addresses computationally demanding challenges in biology and medicine. This highly interdisciplinary field includes data mining, modelling of complex systems, 2D and 3D visualization, signal and image processing and analysis, 'in silico' modelling and simulation, and algorithms for large-scale combinatorial problems.

Researchers from the ISTI Laboratories for Signal and Images, Knowledge Discovery and Delivery and Formal Methods and Tools form an interdisciplinary group whose comprehensive research in a number of areas of bioinformatics has been recently formalized in a Work Package of the national CNR project on 'Computational Biology'.

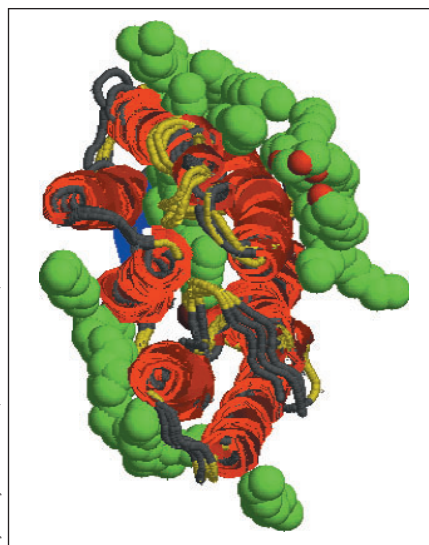
Our main goal is the development of models and analysis methods that can help to describe and understand the spatial characteristics of DNA with a functional value, and the computational

mechanisms behind complex biological systems such as gene regulatory networks. A bottom-up strategy will be adopted, in which low-level processing integrates with high-level classification and modelling. The focus will be on the structural analysis of genomes and proteins, and on the detection and functional analysis of clusters of genes related to underlying biological processes in microarray experiments.

A large number of genomes, ranging from viral and microbial pathogens to higher organisms, have now been fully sequenced and made publicly available for investigations at various levels. Nevertheless, although DNA sequencing is a mature technique and many research efforts to further improve the algorithmic phase are reported in the literature, accurate identification of bases has not yet been fully achieved by the software of available automatic sequencing machines. In this respect, we are currently studying unsupervised statistical techniques to model electrophoresis signals and correct the colour cross-talk and peak-spreading phenomena. At the genome scale, we have developed efficient algorithms for fragment assembly by partial overlap in the shotgun sequencing method. As per high-level processing, we are working on comparative genomics for the identification of conserved and invariant structural elements with functional value within the genomes. Special attention is being paid to the large portion of non-coding regions.

In proteomics, we take advanced techniques for mining complex and high-dimensional information spaces, and apply them to frequent local pattern discovery in protein databases, and to the alignment of proteins at the various structural levels, with the aim of finding common functional characteristics. Knowledge discovery and representation methods will be then exploited as knowledge-based adaptive systems for decision support in medicine and surgery (eg for studying autoimmunity mechanisms and for compatibility testing in organ transplant surgery).

Thanks to recent advances in microarray technology, we are now able to monitor the activity of a whole genome under



by courtesy of Paolo Guadagni, Institute of Biophysics CNR, Pisa

Figure 1: 3D structure of a photoreceptor protein of *Euglena gracilis*.

multiple experimental conditions. Large amounts of data are becoming available, providing simultaneous measurements of expression profiles and of interactions of thousands of genes. The challenge is to discover the complex functional dependencies underlying these data and to identify biological processes driving gene coregulation. At ISTI, techniques for unsupervised clustering of gene expression maps from microarray data are now being investigated. In particular, we are studying statistical techniques of Blind Source Separation, such as Independent Component Analysis (ICA), nonlinear and constrained ICA, and Dependent Component Analysis, which should provide non-mutually exclusive gene clusters. The results of these analyses will be compared with those of local pattern discovery strate-

gies such as constraint-based mining, and possibly used as input to sophisticated clustering techniques. The ultimate goal is to provide simulations and modelling of molecular interactions and metabolic pathways. In this respect, we are also studying formal methods that can be used to describe complex biological systems and verify their properties. Due to the real and massive parallelism involved in molecular interactions, investigations into the exploitation of biomolecular models as examples of global and parallel computing are also in progress.

The research activity described above is carried out in collaboration with other institutions in the fields of biomedicine and informatics. The biomedical institutions provide us with data and validate the biological significance of the results. Our main collaborations are with the Institute of Biophysics, CNR, Pisa, the National Institute for Applied Sciences (INSA) in Lyon and the Immunohematology Unit, II Pisa Hospital Cisanello. We intend to establish new collaborations with other bioinformatics groups, and in particular we are seeking fruitful interactions within ERCIM.

Link:
<http://www.isti.cnr.it/ResearchUnits/Labs/si-lab/ComputationalBiologyGroup.html>

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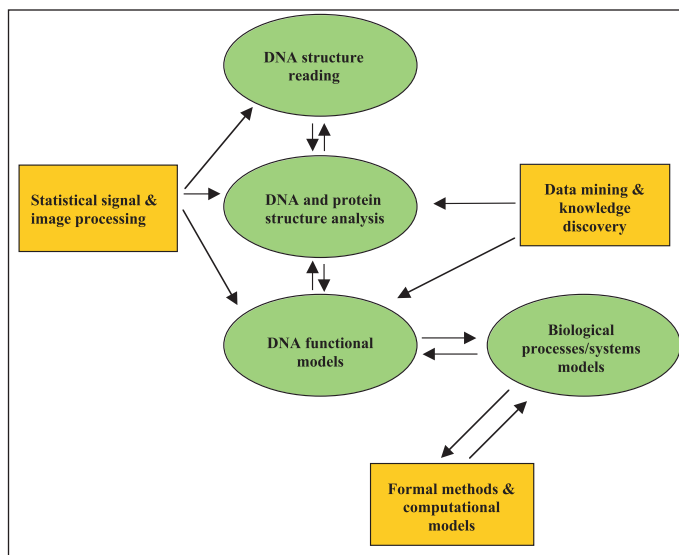


Figure 2: Computational Biology at ISTI-CNR.



Numerical Mathematics Consortium

Scilab-publisher INRIA, National Instruments, Mathsoft and Maplesoft created the Numerical Mathematics Consortium and provide the foundations for a new generation of scientific software.

INRIA, National Instruments, Mathsoft and Maplesoft created the 'Numerical Mathematics Consortium' (NMC). These mathematical software publishers as well as individuals from industry and academia are collaborating to define a consistent and manageable foundation for numerical mathematics.

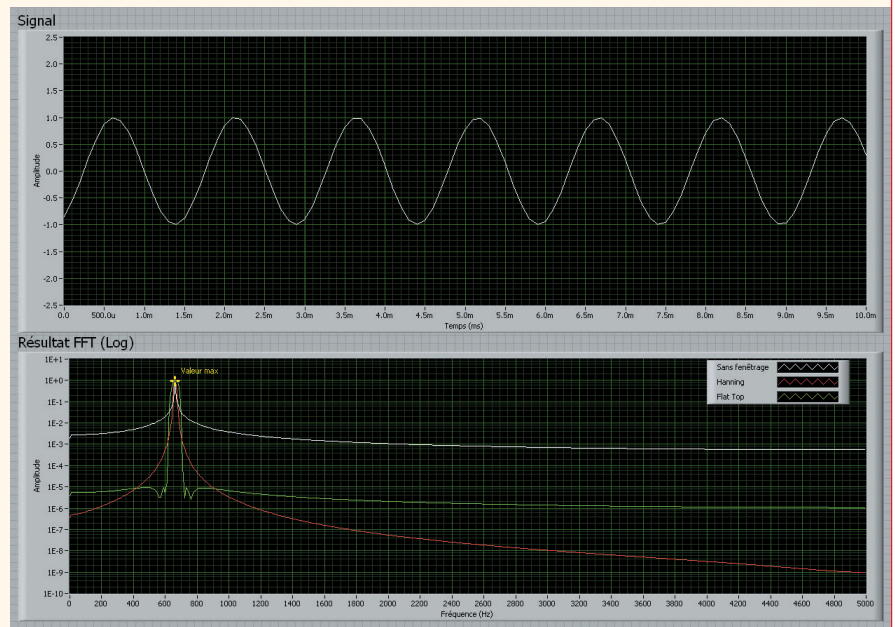
Announced initially in August in the USA, the NMC has been announced in Europe on November 17 by INRIA which is in charge of its development in Europe.

The initial objective of the Numerical Mathematics Consortium is to create an open mathematical semantics standard for numerical algorithm development to enable portability and reuse among tools, platforms and disciplines.

The Numerical Mathematics Consortium's objective is to create a specification that stipulates core mathematical function definitions and semantics applicable to numeric algorithms. These algorithms can then be implemented in a wide variety of application areas such as industrial control, embedded design and scientific research, as well as be easily shared among researchers and developers in industry and academia. The group expects to complete a first release of the standard by next fall.

Numerical calculation, simulation and control as well as embedded design are major disciplines for industry and research. In these fields, incompatibility, unfortunately, prevails in a chronic way because, nowadays, semantics of mathematical functions can vary considerably from software to other. Each tool proposes its own set of functions, and it is often necessary to rewrite the precious algorithms at the time of new projects or when new technologies are implemented. A standard set of mathematical functions based on common semantics will allow both portable solutions and ready-to-use libraries and tools under numerous environments. The technological, scientific and financial stakes are thus more than significant.

INRIA brings a proven know-how in this field, thanks to Scilab, a free open source numerical computation software produced by the Scilab Consortium hosted by the Institute.



The Fast Fourier Transform (FFT)— a discrete Fourier transform algorithm — perfectly illustrates the need to standardize the semantic of functions. This algorithm, applied to the same domain returns a different result according to whether one uses Mathcad or Matlab/Scilab software. Both results are correct. Explanation: semantics differs!

The software which is downloaded, each month, by more than 15,000 new users in the world, meets a growing success.

The founding members of the Numerical Mathematics Consortium invite companies, research centres, universities and individuals who wish to take an active role in standardizing numerical mathematics to join the Consortium.

Links:

<http://www.nmconsortium.org>
<http://www.scilab.org>

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CORRECT – Developing Fault-Tolerant Distributed Systems

by Alfredo Capozucca, Barbara Gallina, Nicolas Guelfi, Patrizio Pelliccione and Alexander Romanovsky

The CORRECT project — rigorous stepwise development of complex fault-tolerant distributed systems: from architectural description to Java implementation — is an international project that aims to provide methodological support for developing fault-tolerant distributed systems in a cost-effective way. The proposed architecture-based methodology covers all phases of system development, from requirement specification to implementation. It is built on a Model-Driven Architecture methodology that automatically generates Java code from a UML-based software architecture description by means of semi-formal refinements.

Software and hardware systems have become widely used in many sectors, including manufacturing, aerospace, transportation, communication, energy and healthcare. Failures due to software or hardware malfunctions or malicious intentions can have economic consequences, but can also endanger human life. There is clearly a growing need for these systems to meet the highest dependability requirements.

Software Architectures (SA) involved in Model-Driven Engineering (MDE) techniques help to develop a system blueprint that can be validated and can guide all phases of system development. There are still many challenging issues in this area, in particular the integration of a new methodology into the industrial software-development life cycle, and in relating the results obtained by SA-based analysis to requirements and coding.

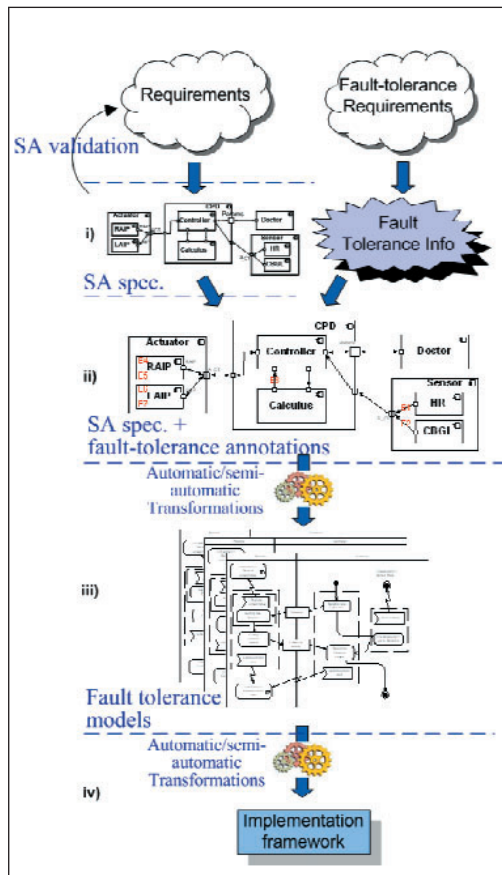
This situation has motivated the investigation of a new architecture-centric method for developing families of complex fault-tolerant distributed systems. This effort is conducted by the Software Engineering Competence Center at the University of Luxembourg (SE2C) in collaboration with the University of Newcastle upon Tyne (UK), in the context of the CORRECT project. CORRECT is a three-year (2004-2006) project, entirely funded by the Luxembourg Ministry of Higher Education and Research. This architecture-based methodology covers all phases of system development, from requirements specification

all the way to system implementation. As graphically summarized in the figure, it consists of four steps:

- *Step 1: SA specification:* initially, an SA specification (described in some architectural language) is produced to model architectural concepts such as components, connectors, ports and configurations. This specification takes into account normal (ie expected) behaviour, while leaving

exceptional behaviour unspecified. The dependability of such an SA specification may be verified with SA-related analysis tools.

- *Step 2: Annotated SA:* software components receive service invocations and return responses when the services are accomplished. The possible responses of a component when implemented and operating are ‘normal’ and ‘exceptional’. While normal responses report those situations where components provide normal services, exceptional responses correspond to errors detected in a component. Therefore, it is natural to design not only normal, but also exceptional behaviour. Similarly to normal behaviour, exceptional behaviour can be elicited from requirements and thus modelled. The goal of this step is to extend the architectural model in order to identify those components or connectors that raise and handle exceptional behaviour. We annotate the architectural model with minimal information, only identifying which component will handle each kind of exception. In contrast, the exception-handling policies are identified later in the process by employing notations and mechanisms specific to fault tolerance. There are a number of reasons for this: the information available at the architectural level could be insufficient to identify how to handle the exception, and, since the handling of exceptions depends strongly on the implementation language selected, we do not want to embed implemen-



CORRECT methodology.

tation-dependent information into the architectural model.

- **Step 3: Model-to-model transformations:** the essence of model-driven development is the idea that a system is incrementally obtained by instantiating and refining a specification of system structure and behaviour. The OMG initiative Model-Driven Architecture (MDA) is an implementation of a more general trend of model-driven development, with the deployment effort focused around industrial standards such as MOF, UML, CWM, QVT etc.

Following the MDA principle, our methodology incorporates proper (automatic or semi-automatic) model-to-model transformation techniques to generate more detailed design models

for handling exceptions. Since these models are typically more informative than the architectural ones, it is generally impossible to derive a complete low-level fault-tolerance model. Some extra information must be added and some refinements are needed. If the relevant architectural language supports a behavioural description, this information can be exploited in order to obtain a more detailed design model. Language- or design-specific exception-handling policies are selected at this level, and are modelled using design-level tools.

- **Step 4: Code generation via transformations:** the next step involves the automatic generation of the application skeleton code from the fault-tolerance design model, via transformation rules.

Since it is usually impossible to generate a complete implementation, what we may reasonably expect is to generate an implementation schema with a set of classes and their methods and exceptions declaration. The role of a programmer is then to write the body of the methods and the code of the exceptional behaviour, while the schema automatically manages exception propagation and orchestration.

Link:

[http://se2c.uni.lu/tiki/tiki-index.php?pt=Research%20Groups\\$ADS:%20Architecture\\$CORRECT&page=CorrectOverview](http://se2c.uni.lu/tiki/tiki-index.php?pt=Research%20Groups$ADS:%20Architecture$CORRECT&page=CorrectOverview)

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The WearIT@work Project: Empowering the Mobile Worker with Wearable Computing

by Elisa Basolu, Massimo Busuoli and Mike Lawo

The European Commission Integrated Project wearIT@work was set up to investigate the feasibility of ‘wearable computing’ as a technology to support the mobile worker. With a total budget of 23.7 million Euro, wearIT@work is the largest project in the world in this area. Based on four different pilot scenarios (emergency, variant production, maintenance and the clinical pathway) the project aims at a user-driven research agenda.

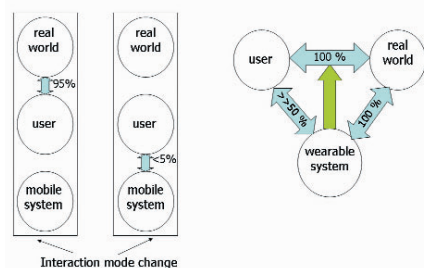
WearIT@work will prove the applicability of computerized clothing, the so-called ‘wearables’, in several industrial environments. The project is user-centric, paying considerable attention to the needs of the end users. A prime goal is to investigate user acceptance of wearables.

There are different approaches to wearable computing depending on the research direction and the application domain. In the wearIT@work project, a major focus is on the interactions between user, system and environment.

In conventional mobile systems, the interaction is based on a modified version of a desktop human computer interface (HCI) and follows the pattern shown on the left side of the figure. To operate the system, users must focus on

the interface. This will capture their attention. Thus, users can either interact with the system or with the environment, but not with both at the same time.

On the contrary, wearable systems allow users to simultaneously interact with the



Interaction between the user, the system and the environment in a conventional mobile system (left) and a wearable system (right).

system and the environment. In addition, there is direct interaction between the system and the environment, and the system can mediate the interaction between the user and the environment.

However, four main issues must be addressed in order to implement wearable interaction concepts.

First, the system must be able to interact with the environment through an array of sensors distributed in different parts of the outfit. In particular it must be able to develop a certain degree of awareness of the user’s activity, physiological and emotional state, and the situation around her/him. This is often referred to as context awareness.

Second, the user interface needs to be operated with minimal cognitive effort and little or no involvement of the hands. In general, a low cognitive load is achieved through an appropriate use of the context information. Thus, for example, instead of having the user select a function from a complex hierarchy of menus, the system should derive the two most preferable options from the context information and present the user with a simple binary choice. In terms of the actual input modality, simple natural methods such as a nod of the head, a simple gesture, or spoken commands are preferred.

Third, the system should be able to perform a wide range of tasks using context information, without any user interaction at all. This includes system self-configuration tasks as well as automatic retrieval, delivery, and recording of information that might be relevant to the user in a specific situation. A trivial example of a context-dependent reconfiguration could be a mobile phone that automatically switches off the ringer during a meeting.

Lastly, the system must be seamlessly integrated in the outfit so that it neither interferes with the users' physical activity nor affects their appearance in any unpleasant way. This means that, unlike many conventional mobile devices, it can be worn nearly anywhere.

Nearly three years of project research activity remain, but the fundamental steps towards a user-centred design approach, a hardware framework and software platform have already been achieved. With the creation of the Open Wearable Computing Group and the annual International Forum on Applied Wearable Computing, a community building process in industry and science has also been initiated. Although miniaturized and low-power computing devices (as well as ubiquitous wireless communication) are still at an emerging stage, it is our intention to exploit the project in order to encourage the wide adoption of wearable computing technology. We aim to provide a wide spectrum of innovative solutions in order to enable wearable computing to be used at any time, in any place and in any situa-

tion. During the project lifetime, a call will be issued for take-up projects to adopt the solutions developed. More information plus details on how to receive the project newsletter with the latest news on developments can be found at the link below.

The wearIT@work collaboration involves 36 R&D groups (mainly from industry), including ENEA, EADS, Skoda, HP, Microsoft, NTT DoCoMo, SAP, Siemens, Thales and Zeiss. The project is coordinated by the Mobile Technology Research Center (TZI) of the University of Bremen.

Link:
<http://www.wearitatwork.com>

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PULSERS Delivers on Phase 1 – Europe to Adopt a Ruling for Ultra-Wideband

by Walter Hirt

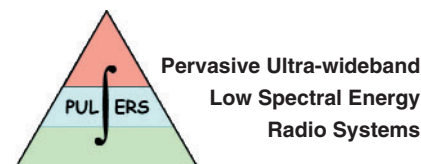
The Electronic Communications Committee (ECC) in the European Conference of Post and Telecommunications Administrations (CEPT) recently completed its public consultation on 'Harmonized conditions for devices using UWB technology in bands below 10.6 GHz'. This action represents an important step towards the introduction of a legal framework in Europe for this emerging – sometimes considered 'disruptive' – ultra-wideband radio technology (UWB-RT). Members of the IST-FP6 Integrated Project PULSERS, which is entirely focused on the advancement of UWB-RT, played an active role in the European regulatory process that led to this milestone result.

The IST-FP6 Integrated Project PULSERS is a consortium of thirty industrial and academic organizations, which was formed to promote UWB-RT: 'Optimally Connected Anywhere and Anytime'. In Phase 1 (2004–2005) of the project, PULSERS introduced and developed new concepts for future short-range wireless systems. The underlying UWB-RT is capable of supporting wire-

less communication and ranging and localization applications, in both traditional and novel use scenarios. When trading data rate versus range, the technology accommodates two complementary classes of systems: (i) systems offering high data rates (HDR) or very high data rates (VHDR) over links of up to a few metres, and (ii) systems supporting low data rates (LDR) alone or combined

with location tracking (LDR-LT), covering distances up to tens of metres (see Figure 1).

PULSERS conceived HDR/VHDR systems to support a number of applications in the home and office environments, such as wireless video connections and wireless high-speed connections for computing equipment. The newly intro-



duced class of LDR-LT devices combines low-rate data-transfer capabilities with precise ranging and location tracking, particularly for indoor environments; these features are increasingly being requested in wireless sensing and control applications. During the first two years of the project, PULSERS established significant results in the following technical areas:

- *User Application Scenarios* – user scenarios and business applications applying the unique technical properties of UWB-RT were defined and their market potential was assessed.
- *System Concepts* – single and multiple antenna systems (SAS, MAS) were designed or investigated. SAS designs partly benefited from the results of UWB-related FP5 projects, whereas fundamental theoretical investigations were necessary for MAS.
- *PHY Concepts* – novel physical layer (PHY) concepts for HDR/VHDR and LDR-LT devices were developed and issues related to their interoperability explored and assessed.
- *MAC Concepts* – medium access control (MAC) functions were modelled and designed for HDR and LDR-LT devices, with an emphasis on cross-layer issues between MAC and PHY.
- *Enabling Technologies* – high-speed, mixed-signal semiconductor processes were exploited to verify the designs of critical analogue/digital building blocks; UWB antenna designs were advanced.

Regulation and Standards

A specific work package in PULSERS addressed the complex issues related to the spectrum regulation and technical standardization of UWB-RT. UWB-RT is often referred to as a ‘disruptive’ radio technology because the premise of UWB-RT is founded on reusing frequency bands already assigned to incumbent radiocommunication services. This is done by spreading signals of very low power (ie less than one thousandth of the power emitted by a cellular phone) over bandwidths of up to several Gigahertz. Understandably therefore, spectrum-granting administrations, licence-holding operators and other stakeholders of spectrum resources have expressed their concerns that UWB-RT will interfere

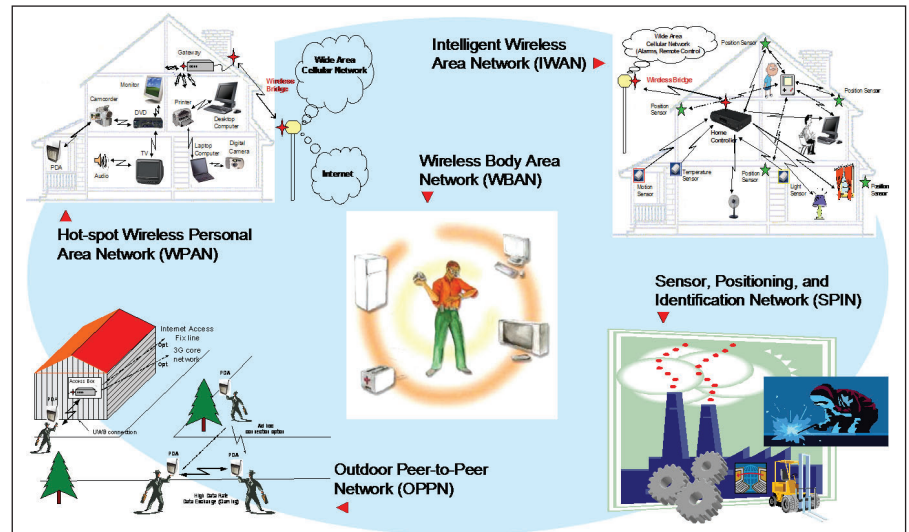


Figure 1: Envisaged application scenarios for short-range wireless systems based on UWB-RT (see also D. Porcino and W. Hirt, ‘Ultra-Wideband Radio Technology: Potential and Challenges Ahead,’ IEEE Commun. Mag., July 2003, pp. 66-74; the WBAN illustration is courtesy of the WWRF).

with existing and future (viz. 4G) radio-communication services.

Members of PULSERS have addressed these legitimate concerns through technical studies, and the results have been made available to European and other international bodies engaged in UWB-related harmonization processes. This required close cooperation with key external industrial organizations promoting the deployment of UWB-RT (eg WiMedia Alliance and UWB Forum). In addition, members of PULSERS maintained a constructive liaison with the European Commission’s DG INFSO B4 (Radio Spectrum Policy). DG INFSO B4 holds the authoritative stakes for the final decision on the regulatory conditions that will govern the deployment of UWB-RT in the European Union. It was significant that the Electronic Communications Committee in the CEPT (European Conference of Post and Tele-communications Administrations) recently completed its public consultation on the ‘Harmonized conditions for devices using UWB technology in bands below 10.6 GHz’. While the final outcome of this action is still pending, this action represents an important step towards the introduction of a legal framework in Europe for UWB-RT, which is now scheduled for mid 2006.

The prospects for arriving at a commercially viable UWB-spectrum regulation in Europe are therefore intact, albeit not to the same extent as in the United States of America, where the legal use and marketing of UWB-RT was authorized in early 2002. A technically and commercially sound regulatory framework for UWB-RT needs to be established in Europe: one that also accommodates the protection needs of affected spectrum stakeholders. This is a key prerequisite for the successful introduction of harmonized technical standards and essential for establishing a viable European ecosystem based on UWB-RT. A favourable status quo of UWB-RT in Europe and beyond would provide significant benefits to consumers and businesses alike and would help to sustain the success of PULSERS in Phase 2.

Links:

<http://www.pulsers.net>
<http://www.cordis.lu/ist/ct/proclu/p/projects.htm>

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Specification Language (HLPSL). The HLPSL is an expressive, modular, role-based, formal language that is used to specify control-flow patterns, data-structures, alternative intruder models and complex security properties, as well as different cryptographic primitives and their algebraic properties. These features make HLPSL well suited for specifying modern, industrial-scale protocols.

In order to demonstrate the effectiveness of AVISPA, we selected a substantial set of security problems associated with protocols that have recently been, or are currently being standardized by organizations like the Internet Engineering Task Force IETF. We then formalized a

large subset of these protocols in HLPSL. The result of this specification effort is the AVISPA Library (publicly available on the AVISPA Web site), which at present comprises 215 security problems derived from 48 protocols. Most of the problems in the library can be solved by the AVISPA tool in a few seconds. Moreover, AVISPA detected a number of previously unknown attacks on some of the protocols analysed, eg on some protocols of the ISO-PK family, on the IKEv2-DS protocol, and on the H.530 protocol.

The AVISPA tool can be freely accessed either through its Web-based interface or by downloading and installing the soft-

ware distribution. For more details, please refer to the AVISPA Web site.

AVISPA has been developed in the context of the FET Open Project IST-2001-39252 'AVISPA: Automated Validation of Internet Security Protocols and Applications', in collaboration with the University of Genova, INRIA Lorraine, ETH Zurich and Siemens Munich.

Link:

<http://www.avispa-project.org>

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Prague Texture Segmentation Data Generator and Benchmark

by Stanislav Mikeš and Michal Haindl

The Prague texture segmentation data-generator and benchmark is a Web-based service developed as a part of the MUSCLE Network of Excellence. It is designed to mutually compare and rank different texture segmenters and to support new segmentation and classification methods development. It can be easily used for other applications such as feature selection, image compression, and query by pictorial example.

Unsupervised or supervised texture segmentation is the prerequisite for successful content-based image retrieval, automatic acquisition of virtual models, quality control, security, medical applications and many others. Although many methods have already been published, this problem is still far from being solved. This is partly due to the lack of reliable performance comparisons between the different techniques. Rather than advancing the most promising image segmentation approaches, researchers often publish algorithms that are distinguished only by being sufficiently different from previously published algorithms. The optimal alternative is to check several variants of a method being developed and to carefully compare results with the state of the art. Unfortunately, this is impractical, since most methods are too complicated and insufficiently described to be implemented with acceptable effort. We were

facing similar problems during our texture segmentation research, and for this reason we implemented a solution in the form of a Web-based data generator and benchmark software.

The goal of the benchmark is to produce a score for an algorithm's performance. This is done so that different algorithms can be compared, and so that progress toward human-level segmentation performance can be tracked and measured over time. The benchmark operates either in full mode for registered users (unrestricted mode - U) or in a restricted mode. The major difference is that the restricted operational mode does not store a visitor's data (results, algorithm details etc) in its online database, and does not allow custom mosaics creation. To be able to use the complete and unrestricted benchmark functionality, registration is required.

The benchmark allows users to:

- obtain customized texture mosaics (U) or benchmark sets and their corresponding ground truth
- evaluate working segmentation results and compare them with state-of-the-art algorithms
- update the benchmark database (U) with an algorithm (reference, abstract, benchmark results) and use it for the benchmarking of subsequent algorithms
- check single mosaic evaluation details (criteria values and resulting thematic maps)
- rank segmentation algorithms according to the most common benchmark criteria and receive the resulting LaTeX-coded criteria tables (U).

Benchmark datasets are computer-generated random mosaics filled with randomly selected textures. Both generated texture mosaics and the benchmarks are

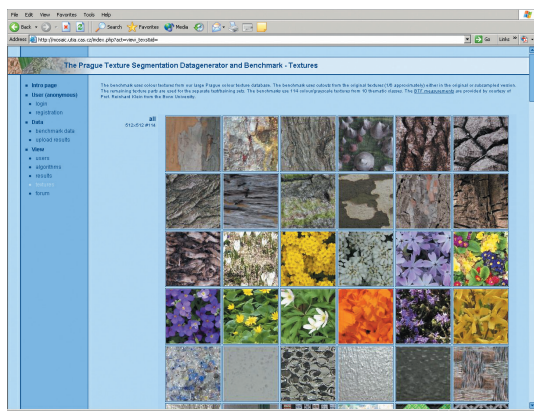


Figure 1: Benchmark colour textures.



Figure 2: Example of a texture mosaic, ground truth and segmentation result.

composed from the following texture types: (i) monospectral textures (derived from the corresponding multispectral textures), (ii) multispectral textures, and (iii) BTF (bi-directional texture function) textures.

The benchmark uses colour textures from our Prague colour texture database, which contains over 1000 high-resolution colour textures categorized into ten

thematic classes. The benchmark uses cut-outs from the original textures (1/6 approximately) either in the original resolution or a sub-sampled version. The remaining parts of the textures are used for separate test or training sets in the benchmark-supervised mode. The benchmarks use 114 colour/greyscale textures from ten classes. The BTF measurements are provided courtesy of Prof. Reinhard Klein from Bonn University.

Colour, greyscale or BTF benchmarks are generated upon request in three quantities (normal=20, large=80, huge=180 test mosaics). For each texture mosaic the corresponding ground truth and mask images are also included.

The test mosaic layouts and each cell texture membership are randomly generated, but identical initialization of the corresponding random generators is used, so that the requested benchmark sets (for the same size and type) are identical for each visitor.

The submitted benchmark results are evaluated and stored (U) in the server database and used for the algorithm ranking according to a chosen criterion.

We have implemented the most frequented nineteen evaluation criteria categorized into three groups: region-based (5), pixel-wise (12) and consistency measures (2). The performance criteria mutually compare ground truth image regions with the corresponding machine-segmented regions. The region-based criteria are correct, over-segmentation, under-segmentation, missed and noise. Our pixel-wise criteria group contains the most frequented classification criteria such as omission and commission errors, class accuracy, recall, precision etc. Finally the last criteria set incorporates the global and local consistency errors. The evaluation table is re-ordered according to the chosen criterion. For each compared algorithm there is a concise description available, eg author, algorithm details, BIB entry and WWW external page.

Links:
<http://mosaic.utia.cas.cz>
<http://www.utia.cas.cz/RO>
 BTF measurements (courtesy of Prof. Reinhard Klein):
<http://btf.cs.uni-bonn.de/index.html>

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Visiting Hybrid Museums: A Colony of Ants in your Pocket

by Javier Jaén and José A. Mocholí

Tangible and intangible digital objects in areas of cultural heritage are becoming increasingly interrelated. Intangible multimedia objects provide contextualization and additional information that aids in the understanding of artistic creative processes. These types of interrelated information must therefore be made available for museum visitors, so that they may have a more enriching experience. This note reports on our experience in the use of evolutionary algorithms based on ant colonies for the efficient provision of dynamic time-constrained visits in Hybrid Museums.

One of the most enriching and exciting experiences that differentiates human beings from other animals is our ability to use expressions of artistic or cultural work to stimulate our senses and to experience a range of emotions. As a

result, in the cultural domain, there is a mandate to save not only the artistic expressions from earlier times, but also the commentaries, reflections and knowledge relationships relating to these expressions. In this way, we avoid

dangers such as forgetting the past and destroying memory.

In this respect, digital culture must face a number of challenges in the coming decades. First, it must provide adequate

multimedia expressions for both tangible and intangible heritage. Second, these new multimedia and multimodal forms of culture must be properly conserved and preserved. Third, both tangible and intangible cultural expressions must be properly interrelated with respect to different awareness contexts or dimensions. Lastly, the resulting vast amount of distributed and interrelated cultural information must be properly delivered to the end users. This should be done with simple navigation or exploration mechanisms that are intuitive and hide the inherent complexity of the different forms of interrelated heritage.

The MoMo project, a collaboration between the Polytechnic University of Valencia in Spain and the Microsoft Research Labs (Cambridge), is a step towards solving these challenges in the context of hybrid museums (HMs). HMs are known as infrastructures that enable the exploration of traditional museums with the assistance of wireless Personal Digital Assistants (PDAs) that have multimedia capabilities and are able to adapt dynamically to visitors' preferences and behaviour. However, as the number of cultural elements and amount of interrelated information grows, visitors need some form of automatic assistance in deciding how to visit as many popular artworks (those belonging to the most relevant artists) as possible within their available time.

This problem, which has traditionally been known as the Orienteering Problem (OP), is a combinatorial problem that cannot be solved in polynomial time. Moreover, in the case of museums where nodes in the OP graph are artworks, the sizes of typical OP instances are in the thousands of nodes. Therefore, solving such instances with exact algorithms is not a feasible approach. Instead, mechanisms based on heuristics are more suitable. In particular, our research makes use of evolutionary algorithms inspired by the natural behaviour of ant colonies to provide efficient and high-quality solutions to this problem. Ant colonies are insect societies that accomplish complex tasks by presenting highly structured organizations and communication mechanisms. Ant behaviour is based on the use of pheromones, and in particular

the trail pheromone. This chemical is used to mark paths on the ground from food sources to the nest. Several experiments have shown that this communication mechanism is very effective in finding the shortest paths and as a result, has inspired several stochastic models that describe the dynamics of these colonies.

Ant Colonies optimization algorithms are effective heuristics for solving problems of medium size (hundreds of nodes). However, the computational cost when dealing with the thousands of nodes of a museum is prohibitive, because visitors are not willing to wait several minutes (even half an hour) to obtain a reasonable solution. Instead, our strategy has been to solve large OP instances with thousands of nodes by partitioning the search space into subspaces and then solving the subproblems. This is done with the help of a Grid computing infrastructure with no communication for synchronization purposes among the worker nodes of the infrastructure. Our mechanism can be seen as a master-slave approach like that proposed by Middendorf, but with no pheromone matrix propagation because the slaves work on independent instances.

The results we have obtained prove that instances of this problem of up to several thousand elements can be solved within a few seconds. Moreover, because we have implemented this distributed infrastructure with the .NET technology, not only desktop PCs but also the handheld devices that are present in the HM can host ant colonies. Figure 1 shows an example of a computation obtained for El Prado museum, where the red rooms are the most attractive ones and the blue ones are the least. It can be observed that the collective effort of ants obtains a path that visits most of the popular rooms within the specified available time.

This evolutionary approach, together with some additional intelligent prediction components, contributes to more exciting and enriching museum experiences and could be the foundation for museums that provide more effective guidance to visitors in the near future.

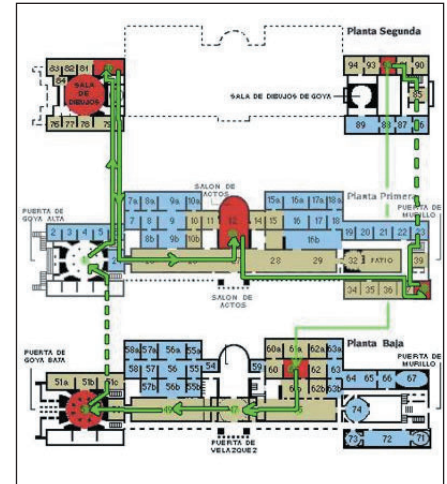


Figure 1: Ant Colony solution at El Prado Museum.

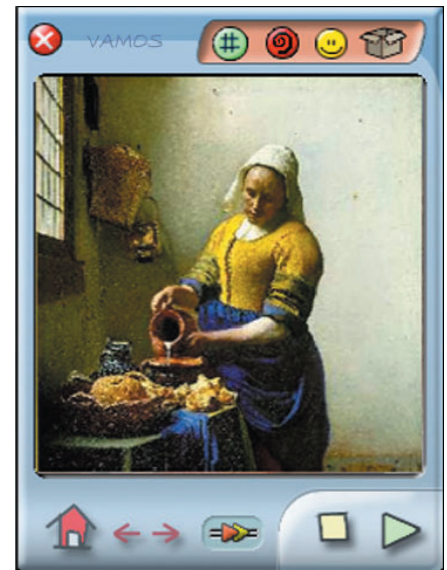


Figure 2: MoMo's Graphical User Interface.

Links:

<http://momo02.dsic.upv.es>
<http://iridia.ulb.ac.be/~mdorigo/ACO/ACO.html>
<http://research.microsoft.com/aboutmsr/labs/cambridge/default.aspx>

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Edutainment and Game Theory Realization through an Open-Source UNESCO Virtual Persepolis Project

by Sepideh Chakaveh, Stefan Werning and Olaf Geuer

The 'Virtual Persepolis' project applies current online game theories to a historical event. The original idea was developed in a Master thesis at the Fraunhofer Institute for Media Communication and the ERCIM E-Learning Working Group.

This year the Nobel Prize in Economic Sciences was awarded to two game theorists. Robert J. Aumann, an Israeli-American, and Thomas C. Schelling, a US citizen, defined chess-like strategies in politics and business that can be applied to arms races, price wars and actual warfare. Game theory is a distinct and interdisciplinary approach to the study of human behaviour. The disciplines most involved in game theory are mathematics, economics and the other social and behavioural sciences. Game theory (like computational theory and so many other contributions) was founded by the great mathematician John von Neumann. The first important book on the subject was *The Theory of Games and Economic Behaviour*, which von Neumann wrote in collaboration with the great mathematical economist, Oskar Morgenstern.

Principals of Game Theory

The application of game theory in economics relies on the assumption that individuals are absolutely rational in their economic choices. In particular it is assumed that each person maximizes her or his rewards – that is, profits, incomes or subjective benefits – in the circumstances that she or he faces. This hypothesis serves a double purpose in the study of the allocation of resources.

Economics is not the only subject associated with game theory: psychology is another field within which, through the theory of social situations, game theory is interwoven. Although here the relevance is more to parlour games such as poker or bridge, most research focuses on how groups of people interact.

The strength of game theory lies in the fact that no parameter is fixed. Only the boundaries are predefined, since decisions must be made in accordance with the status quo. This idea is not new in computer science, as it defines a quintessential element of decision-making in almost all autonomous systems. A simple analogy is a robot moving on a course: when it encounters an obstacle, it must decide which route to take in order to arrive at its final goal. In some cases the robot may also decide whether to move over the obstacle, if the dimensions or materials permit.

Edutainment and Game Theory

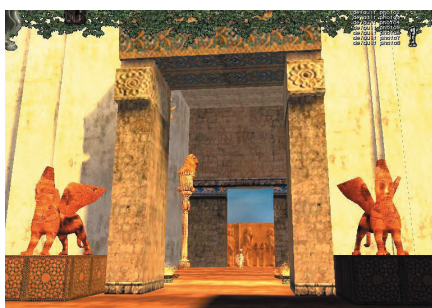
In the recent years, educational research has shown that peer-to-peer teaching reinforces mastery. Moreover, educators have recognized the value of practical experience and competition. For instance, students can design and build robots which then compete against one other in navigating through an obstacle

course. However, a lack of resources or other factors may limit the situations in which this is possible. In contrast, a computer simulation of such a competition would enable more rapid prototyping and further refinement, and could expand the total number of students who can properly share in the experience. Games may also enable teachers to observe their students' problem-solving strategies in action and to assess their performance in realistic situations. Teachers may also demonstrate a particularly difficult problem during a lecture and discuss possible solutions. After all, demonstrating the principles of Newtonian physics using gears, pulleys and levers may be more compelling than chalk on the blackboard. It is not just that games can help one do better on the test; games could become the test.

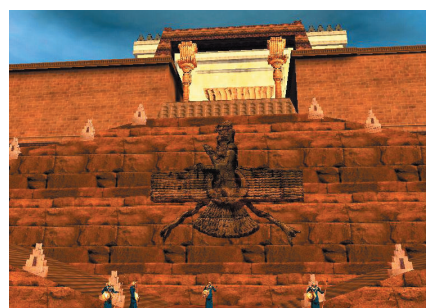
Virtual Persepolis Project

The original idea for this project was first developed in a Masters thesis in 2003, at the Fraunhofer Institute IMK and the ERCIM E-Learning Working Group. In this research, MULE (Multi-User Learning Environment) systems and actual online game theories are applied to historical events. The Virtual Persepolis project was implemented through an appropriate Internet 3D Game Engine. The visualization centred on a reconstruction of part of the Apadana Palace.

In this scenario, a tutor can use rich multimedia tools (eg pictures, 2D and 3D animations, maps, music, audio and video) to illustrate architectural, historical and cultural facts. The players of the game (in this case represented by Persian Guards) are simulated by avatars, each of which bears a national and cultural identity described by the predefined



Persepolis Project screenshots.



parameters of game theory. Persian soldiers with appropriate decision-making capabilities were realized through Artificial Intelligence (AI), which are variables in this programme. This could for instance depend on which side of the Apadana Palace one would face them and which route they take in the palace.

The principle of collaborative learning through role playing and interactive virtual systems allows the user to experience an event as it unfolds, and thus learn to make appropriate decisions on the fly. This is of course only true when the input

parameters and boundaries are assumed to be accurate and realistic. This implies that the decisions made by virtual characters (or players) based on AI can only be correctly determined when the defined parameters are realistic.

Tying advances in Web-based edutainment systems to the sound and challenging concepts of game theory allows interesting areas of research to be explored that are not bounded by computer science alone. With the application of low-end virtual reality and artificial intelligence, a number of long-awaited

scenarios may be simulated by anyone who has access to the Internet. This provides a unique and powerful tool for learning, planning and experiencing events which until very recently were limited to the very privileged.

Link:

<http://mats.imk.fraunhofer.de/e-learning/>

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CONFIOUS: Conference Management System with Intelligence, Power and Style

by Manos Papagelis and Dimitris Plexousakis

Confious is a state-of-the-art conference management system that combines modern design, sophisticated algorithms and a powerful engine to efficiently support the submission and reviewing process of an academic conference or workshop and to help Program Committee Chairs and members to effortlessly carry out complicated tasks.

Most scientific communities have recently established policies and mechanisms to put into practice electronic conference management, mainly by exploiting the Internet as the communication and cooperation infrastructure. Their foremost objective is to minimize the organizational effort and reduce communication costs, while maintaining high quality reviewing and ensuring the fairness of the evaluation. With the intention of supporting scientific committees in this process (see figure), we have designed and implemented Confious, a state-of-the-art conference management system. Confious provides mechanisms for the efficient management of scientific data, intelligent identification and analysis of constraints during the reviewing process, enhanced monitoring and reporting of critical actions and better communication among users.

Main Features

Instant Conference Setup: Confious is provided as a Web service, which means that it is able to support multiple confer-

ences in parallel, transparent between each other. Moreover, there is no need for installations on the conference organizer side. Quite the opposite, a conference is hosted on the server side, and it can accept submissions immediately after customization.

100% Online, Role-Based Collaboration: Confious distinguishes between four types of users: Program Committee Chair, Meta-Reviewer, Reviewer and Contact Person.

Intelligent Management of Conflicts of Interest: A conflict of interest is defined when a reviewer does not feel comfortable reviewing a paper because of some kind of relationship with one or more of the paper's authors. Confious provides an easy way to effectively identify and handle all conflicts of interest and thereby avert certain assignments.

Automatic Assignment of Papers to Reviewers: Program Committee Chair has the option of assigning papers either



Submission and reviewing process of an academic conference or workshop.

automatically or manually. The most advantageous process includes an automatic assignment by the system followed by manual adjustment of assignments by the chair. The automatic assignment algorithm takes into consideration the following constraints:

- matches between paper topics and reviewer interests
- bids of reviewers to specific papers
- conflicts of interest between reviewers and papers
- workload balance to ensure that papers are normally distributed to reviewers.

Dynamic Construction of the Review Form: The online review form is com-

pleted by reviewers during the reviewing process. Instead of using static review forms that have the same format, Confious provides the Chair with the option of constructing or customizing a review form. This is one of the most advantageous features of Confious since it enables high-quality reviewing and yet is not supported by most other conference management systems.

Hierarchical Reviewing Support: The distinction between reviewers and meta-reviewers enables a hierarchical reviewing process. This process ensures high-quality reviewing by providing a better means of control over the submitted reviews.

Decision-Making Based on Paper Classification: One of the most challenging and time-consuming tasks that the Chair is in charge of is to decide on the sets of papers that are going to be accepted or rejected. Actually, it is hard to reduce the results of several reviews into a single meaningful score. Confious classifies the papers into five meaningful

classes and then orders the papers in each class separately.

Workflow Management through Phases: The reviewing and submission process is divided into several phases that enable more efficient management and monitoring of the tasks that are being performed at any given moment.

Enhanced Monitoring, Reporting and Communication Service: Confious provides a monitoring and reporting service that spans the most essential tasks of the system. Furthermore, straightforward customization of e-mails enables better communication between the Chairs, the reviewers and the authors.

Transaction-Based Operations: Data inconsistencies are very common to Web information systems. They can arise due to network instabilities, power cut-offs or other reasons and may result in serious conflicts during the reviewing process. Database operations in Confious are based on transactions to ensure that data always remains consistent.

Task-Oriented Design: Confious is based on a goal-oriented design that facilitates the management and administration of a conference, enhances productivity and advances creativity. Special attention has been paid to effortlessly bringing tasks to an end, providing quick responses to user requests and permitting access even from low-speed connections.

Commentary: We are confident that the rational and algorithmic ground on which we have designed and developed Confious will catch the attention of conference organizers, and will exert a pull on scientific committees to consider it for their future conferences. The interested reader is encouraged to visit Confious online, in order to obtain a better understanding of the system's features through a demonstration conference or through an up-to-the-minute trial conference.

Link:
<http://confious.ics.forth.gr>

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Advertisement



**Call for Take up Actions
 AXMEDIS Project of the European Commission — <http://www.axmedis.org>**

The Integrated Project AXMEDIS - Automating Production of Cross Media Content for Multi-channel Distribution - requires the participation of new contractors to carry out take-up actions as sub-projects within AXMEDIS project to promote the validation and early application of AXMEDIS technologies via demonstration activity.

AXMEDIS is providing a framework which includes technologies, methods and tools to speed up and optimise content production, protection and distribution, for leisure, entertainment and digital content valorisation and exploitation in general for multi-channel distribution, supporting interoperability of content and DRM.

AXMEDIS aims to meet the challenges of digital-content market demand by: (i) reducing costs for content production and management by applying composition, parallel processing, optimisation techniques for content formatting and representation (format) and workflow control; (ii) reducing distribution and aggregation costs in order to increase accessibility with a Peer-to-Peer platform at Business-to-Business level, which can integrate content management systems and workflows; (iii) providing new methods and tools for innovative, flexible and interoperable Digital Rights Management (DRM), including the exploitation of MPEG-21 and overcoming its limitations, and supporting different business and transactions models.

For the technical details regarding AXMEDIS framework specification please visit AXMEDIS web site on which Tutorials, Specification, Use Cases, Test Cases, and reports about the research activity performed and planned are available. See also

next AXMEDIS conference <http://www.axmedis.org/axmedis2006>
 The candidate topic areas of this call include the followings application and/or extension of the AXMEDIS framework and tools to support:

- one or more distribution channels in order to make evident interoperability of content and tools with other AXMEDIS distribution channels and tools (mobile devices, PC, STB, portable video player, portable music player, etc.)
- massive and/or coordinated production, aggregation, protection, of cross media content; collaboration among different actors of the production and distribution value chain; collaborations among cultural institutions, etc.
- production and/or distribution authoring tools and/or players.

Take up projects should aim at developing real solutions (adoption of the AXMEDIS framework and technology in real-life scenarios) by exploiting AXMEDIS technologies. They should start real sustainable activities by taking advantage of the AXMEDIS framework services and derived tools. Maximum funding is about 1-1.1 million Euro, for the whole 3-4 take up actions.

All the necessary information for submitting your proposal is available at the call webpage of the AXMEDIS project <http://www.axmedis.org/callfortakeup/call.html>

Contact:
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 E-mail: nesi@dsi.unifi.it; <http://www.dsi.unifi.it/~nesi/>

EU-INDIA'05 - Second Annual Conference of the ICT for EU-India Cross Cultural Dissemination Project

by María Alpuente, Santiago Escobar, and Moreno Falaschi

The Second Annual Conference of the 'ICT for EU-India Cross Cultural Dissemination Project', EU-INDIA'05, was held in Valencia, Spain, 14-15 November 2005.

In the framework of the EU-India Economic Cross Cultural Programme, the 'ICT for EU-India Cross Cultural Dissemination Project', coordinated by Prof. Furio Honsell from University Udine, aims at creating a network for developing collaborations and exchanges between European and Indian universities and R&D research centres in the areas of integrating new communication technologies in education and dissemination of entrepreneurial research from academia to business, with particular focus on heritage and e-governance.

The conference was attended by 30 participants from universities and research institutes of the four partner universities Udine, Genoa (both Italy), Valencia (Spain), and Hyderabad (India). The conference was inaugurated by Gumersindo Verdú, vice-chancellor for international actions of the Technical University of Valencia (UPV). The three invited speakers gave highly interesting and stimulating presentations. Jaime Gómez, general director for scientific and technological parks of the Valencian government presented the 'Valencian Government Model for Research and Science Parks'. Juan José Moreno Navarro, international relations head for IST of the Spanish ministry of education and science, described the ICT research activities in Spain and their European and Indian connections. Finally, Salvador Coll, director for new initiatives of the UPV 'Innovation Technical City' (CPI) in Valencia, spoke about research, innovation, challenges, and achievements at the CPI Science Park.

The technical program also included fifteen regular talks organized in six sessions: web categorization, natural language engineering, Web verification and



From left: B.G. Sidharth (Birla Science Centre, Hyderabad), María Alpuente (U. Politécnica de Valencia) and Furio Honsell (University of Udine).

repairing, Web-based declarative connecting tools, digital platforms for artistic collections, and hybrid museum infrastructure.

The conference chairs wish to thank the different institutions and corporations that have supported the event, especially the EU-India project ALA/95/23/2003/077-054, Università degli Studi di Siena, Technical University of Valencia, and the Spanish Ministry of Education and Science.

Link:

EU-INDIA'05:
<http://www.dsic.upv.es/workshops/euindia05/>

Please contact:

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 E-mail: alpuente@dsic.upv.es

7th Workshop of the ERCIM Working Group 'Matrix Computations and Statistics'

The workshop was organized within the framework of the 3rd World conference on Computational Statistics and Data Analysis which was held in Limassol, Cyprus, 28-31 October 2005. Chairman of the conference was Erricos Kontoghiorghes from the university of Cyprus.

Two sessions were organized by the working group:

- Data assimilation and its application: (organized by Z. Zlatev, NERI, Denmark)
Speakers: V. Mallet, G. Dimitriu, Z. Zlatev, F-X Le Dimet, S. Zein.
- QR and other factorizations (organized by B. Philippe, INRIA/IRISA, France)
Speakers: L. Grigori, F. Guyomarc'h, D. di Serafino, J. Barlow.

Links:

The title of the talks and the slides:
<http://www.irisa.fr/sage/wg-statlin/WORKSHOPS/LEMASSOL05/program.html>

WG home page:
<http://www.irisa.fr/sage/wg-statlin/>

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ERCIM News is the magazine of ERCIM. Published quarterly, the newsletter reports on joint actions of the ERCIM partners, and aims to reflect the contribution made by ERCIM to the European Community in Information Technology. Through short articles and news items, it provides a forum for the exchange of information between the institutes and also with the wider scientific community. This issue has a circulation of 10,500 copies. The printed version of ERCIM News has a production cost of 8 Euro per copy. It is available free of charge for certain groups.

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CALL FOR PARTICIPATION

CISTRANA Workshops Series on Coordination of IST Research and National Activities

A series of workshops is being organised in the scope of the CISTRANA project (<http://www.cistrana.org>), whose aim is to achieve coordination of national research programmes with each other and with European programmes in the information technology sector, in order to improve the impact of all research efforts in Europe and to reinforce European competitiveness. The workshops are open to anyone with an interest in the topics. This might include programme and project managers, persons interested in multinational collaborations, developers of research portals, and users of taxonomies in information technology. Leading speakers have been invited, and there will be opportunities for open discussion to reach conclusions that will have a real impact on the future of the European research landscape.

The future workshops are as follows:

- Best practice in multi-national programme collaboration (18 Jan 2006, Cologne, Germany)
- Portals for information dissemination and taxonomies for classification (20-21 February 2006, Abingdon, UK)
- Design of national IST programmes in the context of ERA coordination (9-10 March 2006, Budapest, Hungary)

Registration for the workshops is free but attendees must pay their own travel expenses.

More information:

<http://www.cistrana.org/149.htm>

ERCIM-Sponsored Events

ERCIM sponsors up to ten conferences, workshops and summer schools per year. The funding for all types of events is 2000 Euro.

Conferences

ERCIM invites sponsorship proposals from established conferences with an international reputation, where substantive overlap can be shown between the conference topic and ERCIM areas of activity. Typical cases would include annual conferences in computer science with international programme committees, substantial international participation, and proceedings published with an established international science publisher.

Workshops and Summer Schools

ERCIM sponsors workshops or summer schools (co-) organised by an ERCIM institute. The additional funding provided by ERCIM should be used to enhance the workshop by, for example, increasing the number of external speakers supported.

Next Deadlines for Applications:

- Conferences: 15 April 2006 for conferences later than 15 December 2006
- Workshops and summer schools: 15 April 2006 for workshops and schools later than 15 July 2005

Events sponsored by ERCIM in 2006:

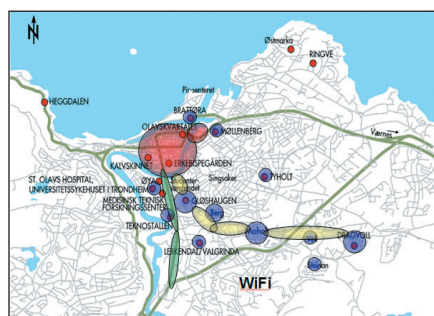
- **SOFSSEM 2006** - 32nd Conference on Current Trends in Theory and Practice of Computer Science, Merin, Czech Republic, 21-27 January 2006
- **World Wide Web Conference 2006**, Edinburgh, UK, 22-26 May 2006
- **CAISE 2006** - 18th Conference on Advanced Information Systems Engineering, Luxembourg, 5-9 June 2006
- **CONCUR 2006** - 17th International Conference on Concurrency Theory, Bonn, Germany, 27-30 August 2006
- **DISC 2006** - the International Symposium on Distributed Computing, Stockholm Sweden, 19-21 September 2006

More information:

<http://www.ercim.org/activity/sponsored.html>

NTNU — The Norwegian University of Science and Technology, NTNU, Trondheim in Norway will soon serve as field test laboratory for wireless broadband information services. NTNU has signed a formal cooperative agreement with the city of Trondheim, the county and the local chamber of commerce to develop a world-class field laboratory for the testing of mobile and nomadic broadband information services. Under the agreement, NTNU will install full wireless coverage for students and staff on the university's campus, and will extend the wireless network to cover the commercial areas of downtown Trondheim.

The goal is to preserve session mobility (roaming) throughout the entire network. The coverage in the first stage of the



Wireless coverage in the Trondheim region.

development will be approximately 5 km², with a target start date of 15 August, 2006.

The first development phase will employ Wi-Fi technology, but will gradually shift to other technologies, such as WiMAX, as the technology matures. Approximately 20,000 university students are expected to comprise the user community for the planned network during the first phase in the autumn of 2006. The Trondheim Wireless City programme is an effort that welcomes outside enterprises, including content and technology providers who would like to test their ideas in the planned field laboratory.

http://www.ntnu.no/ikt/labs/tt/index_e.htm

CWI — TT-Medal Project wins ITEA Achievement Award 2005. The Board of ITEA — Information Technology for European Advancement — selected the TT-Medal project as the winner of the ITEA 2005 Achievement Award. This was announced at the 6th ITEA



Michael Schmidt, Jens Herrman (DaimlerChrysler), Erik Altena (LogicaCMG), Natalia Ioustinova (SEN2, Centrum voor Wiskunde en Informatica), Colin Willcock (Project Manager of TT-Medal, Nokia) at the 6th ITEA Symposium, Helsinki, Finland, 13-14 October, 2005.

Symposium in Helsinki, Finland, 13-14 October 2005. Within TT-Medal (Test & Testing Methodologies for Advanced Languages) researchers developed a generic standardised solution for software system testing. With the results,

European industry can achieve a reduction in test development and test execution time and, at the same time, improve the product quality.

TT-Medal developed methodologies and tools based on the TTCN-3 testing language from the European Telecommunication Standards Institute and introduced them into the European industry. Eleven participants took part in TT-Medal, including three ERCIM members: SEN2 research group of CWI, Fraunhofer Institute for Open Communication Systems FOKUS and VTT. The results provide an opportunity for European test tool suppliers and consultants to position themselves better in a world market that has been dominated by the USA.

<http://www.cwi.nl/sen2>
<http://www.tt-medal.org>

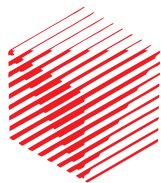
CWI — E-Quality expertise centre for quality of ICT services. With the fast-growing number of new ICT services and applications, it is becoming more difficult to guarantee the required quality levels. To strengthen research in the field of Quality of



Service, CWI, TNO Information and Communication Technology and the University of Twente founded the E-Quality expertise centre in the Netherlands. The official kick-off took place on 30 September 2005 in Enschede. Goals of the new centre are to transfer knowledge to the market, to further expand the knowledge and expertise of the partners of joint projects and to train specialists. The E-Quality participants bring in a wealth of expertise in the area of Quality of Service, each with a different and complementary focus.

INRIA — Objectweb and Orientware signed a memorandum of understanding to promote the adoption of open-source middleware in China. Officials from the Chinese Ministry of Science and Technology (MOST) and INRIA signed the memorandum on 4 November 2005. ObjectWeb is a consortium of leading companies and research organizations to produce next generation of open source middleware. ObjectWeb and its Chinese counterpart Orientware, announced their decision to build a common open source middleware platform and Orientware agreed to release several of its middleware components in open source. It is widely anticipated that future ubiquitous computing environments will be highly dynamic, subject to constant changes and of ever-increasing complexity. This in turn motivates the construction of dynamically configurable software infrastructures to provide a consistent, systematic basis for system evolution, control and management.

contact@objectweb.org



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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