Number 85, April 2011

ERCIM NEWS

European Research Consortium
for Informatics and Mathematics
www.ercim.eu

Special theme:

Unconventional Computing Paradigms

Also in this issue:

ERCIM News is the magazine of ERCIM. Published quarterly, it reports on joint actions of the ERCIM partners, and aims to reflect the contribution made by ERCIM to the European Community in Information Technology and Applied Mathematics. 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 about 9,000 copies. The printed version of ERCIM News has a production cost of €8 per copy. Subscription is currently available free of charge.

ERCIM News is publ ished by ERCIM EEIG
BP 93, F-06902 Sophia Antipolis Cedex, France
Tel: +33 4 9238 5010, E-mail: contact@ercim.eu
Director: Jérôme Chailloux
ISSN 0926-4981

Next issue
July 2011, Special theme: "ICT for Cultural Heritage"

Keynote

Unconventional Computation

The mathematician Stanislaw Ulam is famously quoted as saying that using a term like nonlinear science is like referring to the bulk of zoology as the study of non-elephant animals[1]. Unconventional, or non-classical, computation is a similar term: the study of non-Turing computation. But how big is its associated field? Whereas zoology has the advantage of studying many kinds of non-elephants, non-classical computer scientists are currently restricted to studying a few relatively primitive, or dimly seen, or merely hypothesised, devices.

The elephant in the room here is the classical Turing machine, with its 70-plus years of detailed study. Some maintain that there are only elephants, and that the rest of us are like the blind men in the Indian parable, claiming we have found snakes, and ropes, and walls instead. However, I prefer the reversed parable, illustrated with a cartoon of several blind men groping at said snake, and rope, and wall, and confidently declaring, "yes, it's an elephant!"

The classical Turing machine was developed as an abstraction of how human "computers", clerks following predefined and prescriptive rules, calculated various mathematical tables. The abstraction has proved extremely powerful, yet, as an abstraction, it omits certain features.

Physics

Despite being formulated post-relativity and post-quantum mechanics, classical Turing computation is essentially based in classical physics. This is understandable given the source of its abstraction, but today's nano-scale computer components are embodied in the quantum world. Considerable effort is taken to make them classical again. The study of quantum computing and quantum communication is taking quantum weirdness seriously, and building devices simply impossible to achieve in the classical Turing model. For example, John von Neumann noted that "Any one who considers arithmetical methods of producing random digits is, of course, in a state of sin"[2], yet quantum systems are inherently probabilistic. And the features of General Relativity, where

Susan Stepney, Deptartment of Computer Science, and Centre for Complex Systems Analysis, University of York.

observers, and different parts of the computational device, may experience radically different proper times, have barely been addressed.

Parallelism

Weird physics isn't the only property of the real world not addressed by the classical model. The real world is massively parallel, yet in the classical Turing model parallel computers are no more powerful than sequential ones. A single human clerk, following rules, can calculate exactly the same numerical tables as a whole army of clerks. Of course, the army can do it faster, but in the Turing model, this advantage is swallowed up by simple space versus time tradeoffs. When we are considering real time embedded computer systems, with them interacting with the real world, issues of time become crucial, and parallelism has to be used to meet hard deadlines. One reason parallelism is still a relatively niche study is due to the enormous success in manufacturing computers: Moore's law[3] has enabled sequential machine performance to grow fast enough to cater to our growing everyday needs, and only specialists have needed to go parallel. But recently, Moore's law has taken a new direction: instead of individual chips getting faster, they are going multi-core. If Moore's law continues in this direction, we will soon have kilo-core chips, and we now have to take this everyday parallelism seriously. This will benefit not just for our everyday devices, but also massively parallel cluster-based computation, up to vastly parallel Avogadro-scale computation.

Interaction

The classical Turing model is "ballistic": we give the clerk a set of instructions, shut them in a room, and wait for the answer. Interactive computing is a "guided" model: there is a continual interactive feedback loop between the computation and the real world. The computation here is an open system of closely coupled reciprocal causation, constantly receiving input and changing its behaviour based on that input, constantly providing output and affecting its environment, and hence its own subsequent inputs, through that output.

Nature

The Turing model was inspired by a single paradigm: the actions of human clerks. Unconventional computation can be inspired by the whole of wider nature. We can look to physics (from general relativity and quantum mechanics, to annealing processes, analogue computing, and on to fully embodied computation), to chemistry (reaction-diffusion systems, complex chemical reactions, DNA binding), and to biology (bacteria, flocks, social insects, evolution, growth and self-assembly, immune systems, neural systems), to mention just a few.

Even if it were to turn out that the theoretical power of unconventional computers is no more than classical, the practical power has enormous potential. New problems require new perspectives, new formulations, new conceptual frameworks, new mechanisms, new approaches. Unconventional computation offers these novel opportunities.

Susan Stepney

[1] Campbell, Farmer, Crutchfield, Jen. "Experimental Mathematics: the role of computation in nonlinear science". Comms.ACM 28(4):374-84, 1985

[2] John von Neumann. "Various Techniques Used in Connection With Random Digits." In Householder et al, Monte Carlo Method, National Bureau of Standards,1951

[3] Gordon E. Moore. "Cramming more components onto integrated circuits". Electronics. 38(8):114-7, 1965

RESEARCH AND INNOVATION

This section features news about research activities and innovative developments from European research institutes

EVENTS

IN BRIEF

ERCIM offers fellowships

- in Informatics and Applied Mathematics
- for PhD holders from all over the world
- in leading European research institutes

Application deadline twice per year
30 April and 30 September

Meet us at fet11 in Budapest 4-6 May - www.fet11.eu

fellowship.ercim.eu

MARIE CURIE ACTIONS

ERCIM
European Research Consortium for Informatics and Mathematics

AXES - A New ERCIM-managed Project

"Access to Audiovisual Archives" (AXES) is the name of a new large-scale integrating project (IP) that will investigate innovative solutions for audiovisual content exploration. The project was launched by a kick-off meeting on January 13-14, 2011 at Katholieke Universiteit Leuven (Belgium).

The goal of AXES is to develop tools that provide various types of user with new engaging ways to interact with audiovisual libraries, helping them discover, browse, navigate, search and enrich archives. In particular, apart from a search-oriented scheme, the project will explore how suggestions for audiovisual content exploration can be generated via a myriad of information trails crossing the archive. This will be approached from three perspectives (or axes): users, content, and technology.

Innovative indexing techniques will be developed in close cooperation with a number of user communities through tailored use cases and validation stages. Rather than just starting new investments in technical solutions, the co-development will investigate innovative paradigms of use and novel navigation and search facilities. Targeted users are media professionals, educators, students, amateur researchers and home users.

Based on an existing Open Source service platform for digital libraries, novel navigation and search functionalities will be offered via interfaces tuned to user profiles and workflow. For this purpose, AXES will develop tools for content analysis deploying weakly supervised classification methods.

Information in scripts, audio tracks, wikis or blogs will be used for the cross-modal detection of people, places, events, etc., and for link generation between audiovisual content. Users will be engaged in the annotation process: with the support of selection and feedback tools, they will enable the gradual improvement of tagging performance. AXES technology will open up audiovisual digital libraries, increasing their cultural value and their exposure to the European public and academia at large.

The consortium is a perfect match to the multi-disciplinary nature of the project, with professional content owners, academic and industrial experts in audiovisual analysis, retrieval, and user studies, and partners experienced in system integration and project management. The project comprises thirteen partners including the ERCIM members Fraunhofer Institute for Intelligent Analysis and Information Systems IAIS, INRIA, Katholieke Universiteit Leuven, and Dublin City University. The project started on 1 January 2011 and is managed by ERCIM.

Link:
http://www.axes-project.eu/

Please contact:
Philippe Rohou, AXES project coordinator, ERCIM Office
E-mail: philippe.rohou@ercim.eu

Tinne Tuytelaars
AXES scientific coordinator, KU Leuven, Belgium
E-mail: Tinne.Tuytelaars@esat.kuleuven.be

ERCIM 2011 Cor Baayen Award

Nominate a promising young researcher for the 2011 ERCIM Cor Baayen Award!

Deadline for nominations: 30 April 2011

Each year, ERCIM awards a promising young researcher in computer science and applied mathematics with the Cor Baayen Award. The winner of the award receives €5,000, together with an award certificate. The award will be presented at a ceremony during the 2011 ERCIM fall meetings.

Nominees must have carried out their work in one of the 'ERCIM countries' (ie, Austria, Belgium, Czech Republic, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, Norway, Poland, Portugal, Spain, Sweden, Switzerland, The Netherlands and the United Kingdom). Nominees must have been awarded their PhD (or equivalent) after 30 April 2008.

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.

More information: http://www.ercim.eu/activity/cor-baayen-award

fet[11] The European FutureTechnologies Conference and Exhibition

Budapest 4-6 May 2011

The European Future Technologies Conference and Exhibition 2011 is the second edition of a new forum dedicated to frontier research in information and communication technologies.

Following the first FET conference held in 2009 in Prague, *fet*[11] is designed to be highly interactive and engaging a broad and multi-disciplinary community. It will involve key policy makers, and features a mix of a panel discussion, keynote speakers, scientific sessions, and posters sessions.

Keynotes

Seven visionary keynotes will be presented:

- Josh Bongard: "How Evolution Shapes the Way Roboticists Think"
- Jean-Philippe Bouchaud: "The endogenous dynamics of markets: price impact and feedback loops"
- Rodney Douglas: "Constructive Cortical Computation"
- Artur Ekert: "Is the age of computation yet to begin?"
- John Pendry: "The Science of Invisibility"
- Gábor Prószéky: "The (hopefully near) future of human language technologies"
- Claire Tomlin: "Mathematical models to help understand developmental biology and cancer"

FET Flagship Pilots

Neelie Kroes, Vice-President of the European Commisson will official ly launch six FET Flagship pilot actions which will prepare for FET Flagships. FET Flagships are science-driven, large-scale research partnerships, envisioned to run for at least 10 years starting in 2013.

Exhibits

A hands-on exhibition featuring 28 exhibits will run throughout, in parallel to the conference, showcasing the latest research developments in future and emerging information technologies including flying robots, graphene based devices, and many others.

A Science Café will be open during the whole conference and will offer a casual meeting place for discussions and ignite-style short presentations.

More than a traditional scientific conference, fet11 is thus a unique intellectual event which aims at creating an atmosphere of excitement for the opportunities presented by FET-type research in Europe through its distinctive content and structure.

Opportunity for Young Researchers

fet[11] offers a unique opportunity for doctoral students and young researchers:

- find out what the current state of thinking is from leaders across a broad range of future information science and technology
- share and discuss your ideas in one of our Science Café discussions with leading scientists from around the world
- take your chance to tell leading politicians what you think about the future of science in Europe

Students (limited to 200), journalists and science bloggers can attend *fet*[11] free of charge.

fet[11] is organised by the European Commission Futureand Emerging Technologies program, ERCIM and SZTAKI.

More information:
http:// www.fet11.eu

ERCIM Opens to Multiple Members per Country

The ERCIM consortium is currently re-organising into a two-tier structure: a non-profit association (AISBL) open to any suitable institution based on criteria of excellence, and the current European Economic Interest Group (EEIG) composed of a few members which will act as the host of W3C Europe and the ERCIM office. The association will be able to drive the ERCIM mission without the current restriction of one member organisation per country.

The creation of the ERCIM AISBL is progressing rapidly and it is expected that the first general assembly consisting of all current ERCIM Members will be held in Trondheim on 9-10 June 2011.

Why participate in ERCIM ?

ERCIM is a European-wide open network of centres of excellence in ICT and is internationally recognized as a representative organisation in its field, providing access to all major ICT research groups in Europe.

ERCIM has a track record of successful initiatives promoting ICT research and cooperation in Europe and beyond. Among these are:

- the Cor Baayen Award, awarded each year to a promising young researcher in computer science and applied mathematics. The award consists of a cheque for 5000 Euro together with an award certificate.
- Alain Bensoussan Fellowship Program, supported by the EC, offers fellowships for PhD holders from all over the world hosted in leading European Research Institutes.
- ERCIM News, the quarterly magazine of ERCIM with a print distribution of over 9000 copies, as well as free online access. Through short articles and news items on research and innovation, it provides a forum for the exchange of information between the institutes and also with the wider scientific community.
- Cooperation with professional bodies in domains of interest, such as the European Mathematical Society, the European Telecommunications Standards Institute (ETSI), the European Science Foundation (ESF)
- Organisation of strategic seminars on innovation
- White papers and reports for decision-making bodies such as the EC, eg Cooperations in Grid research between EU and South East Asian countries; Internet in the Mediterranean Region, Tunisian Research in IT, HPCN in the southern Mediterranean Region; Evaluations for the World Bank's INFODEV Programme
- Organization of strategic workshops, eg Beyond-The-Horizon, EU-Mediterranean co-operations, EU-US National Science Foundation strategic workshops
- Research project management support: ERCIM has successfully applied for and managed numerous leading ICT research projects in the range of European Framework Programmes
- Working Groups: ERCIM runs working groups on focussed topics ranging from Computing and Statistics to Software Evolution, preparing the way for excellent research in new domains.

Organisations interested in joining ERCIM are invited to contact the ERCIM office to express their interest. Entry criteria and the process for joining are being finalised and it should be possible to formulate official applications for ERCIM membership from June 2011.

Link: http://www.ercim.eu

Please contact:
ERCIM office, E-mail: contact@ercim.eu

ERCIM MUSCLE Working Group at the World Congress 2011

New York City, USA,
30 August - 3 September 2011

The ERCIM Working Group on Multimedia Understanding through Semantics, Computation and Learning (Muscle) is involved in the scientific support and organization of the World Congress "The frontiers in intelligent data and signal analysis", DSA. The congress features three international conferences plus a number of tutorials, workshops and an industrial exhibition.

The congress combines three international conferences:

- International Conference on Machine Learning and Data Mining, MLDM,
- Industrial Conference on Data Mining, ICDM, and
- International Conference on Mass Data Analysis of Images and Signals in Medicine, Biotechnology, Chemistry and Food Industry, MDA.

A broad range of applications are presented at this congress, including marketing, medical and life-sciences, industry, and agriculture. The World Congress thus responds to all novel aspects of data analysis. Leading scientists from research and industry will be presenting their work and discuss novel ideas. The World Congress is also a platform for companies, decision makers from industry and market, and for networking. Next to the scientific program, interested companies and representatives from industry have the possibility to present their projects on intelligent data and signal analysis.

The main sponsor and organizer of DSA 2011 is Ibai, the Institute of Computer Vision and Applied Computer Sciences, based in Leipzig, Germany and New York City, USA, and member of the ERCIM MUSCLE Working Group. Several MUSCLE members have been collaborating in the congress organization, in the framework of MUSCLE's training and scientific dissemination initiatives.

More information:
http://www.worldcongressdsa.com/
http://wiki.ercim.eu/wg/MUSCLE/

Quantum Computing

by Jiri Vala

We are living at the beginning of a quantum revolution which will no doubt have a profound impact on all aspects of our lives. Quantum systems, which were once restricted to academic research, are now becoming a technological reality. This inevitable evolution is particularly well documented in the context of information and communication technologies where the first quantum devices are becoming available commercially.

This special theme of the ERCIM News brings quantum information science and technology closer to its readers via three invited and three contributed articles which explore various aspects of this fascinating field of research and its exciting applications.

Quantum computation, which is naturally a main focus of this issue, represents a highly unconventional and also extremely powerful computation paradigm. Quantum computation can provide immense computing power that reaches beyond the capabilities of any conventional computer. This power derives from the exotic properties of quantum systems, from quantum 'weirdness' which has no analog in the world of classical mechanics and thus no analog in the world we can perceive directly by our senses. This 'weirdness' reflects the counterintuitive facts that distinct quantum states of a system can coexist in what is called a quantum superposition and can also be entangled by strong correlations which have no classical analog.

Introduction into quantum information and related quantum engineering challenges is provided in the invited article by Thomas Busch from University College Cork who explores the essential principles which are common to all quantum information processing.

The realization of quantum computing faces highly complex challenges, the most important one being protection of quantum information against errors. Engineering approaches have been developed allowing us to achieve fault-tolerant quantum computation in principle. They are based on concatenated quantum error correction schemes, and as such, require a large amount of physical resources and extreme control over each component of the quantum computing process. An attractive alternative, topological quantum computation, has recently emerged which enables fault-tolerance to be built into quantum computing hardware.

Topological quantum computation is presented in the invited article by Joost Slingerland from National University of Ireland, Maynooth. It explains how the quantum 'weirdness' mentioned above can be even more exotic in certain two-dimensional quantum systems which permit quasiparticles called anyons, and how knotting trajectories of these anyons can be exploited for fault-tolerant quantum computation.

Efficient quantum algorithms are keys to harvesting the enormous power of quantum computing. Indeed quantum information science was highly accelerated by the discovery by Peter Shor of quantum algorithm for large number factorization which provides an exponential speedup of computation compared to any conventional (classical) algorithm. Tremendous progress in development of quantum algorithms have been experienced since then. Development of new algorithms is indeed closely related to study of novel paradigms for quantum computation.

Quantum random walks and their role in the development of quantum algorithms is presented in the invited article by Michael Mc Gettrick from National University of Ireland, Galway. The detailed understanding of quantum random walks, including for example the effect of memory on their controllability, is an important step towards new quantum algorithms.

The role of entanglement in the context of quantum algorithms and complexity is addressed in the article by Ashley Montanaro from University of Cambridge who investigates unentangled quantum proofs in Merlin-Arthur games and their applications for efficiently solving hard computational problems. Interesting results in this area have been obtained for example for the 3-SAT problem.

Important developments have taken place in other areas of quantum information processing, particularly in quantum communication and cryptography. While realization of quantum computing as the ultimate quantum information processor is challenging, quantum cryptography and its application for quantum key distribution provide commerically available quantum security.

New quantum cryptographic methods are explored in the article by Harry Buhrman, Serge Fehr, and Christian Schaffner from CWI. Quantum cryptography is also the topic of the article by Martin Stierle and Christoph Pacher from the Austrian Institute of Technology which focuses on high speed quantum key distribution and presents important recent developments towards commercial quantum cryptography.

Please contact:
Jiri Vala
National University of Ireland Maynooth / IUA
E-mail: Jiri.Vala@nuim.ie

Unconventional Computing Paradigms

Molecular and Cellular Computing

by Giancarlo Mauri

In 1994, a pioneering experiment by Leonard Adleman showed that DNA could be used to solve mathematical problems by exploiting its capability to store and process information and using molecular biology tools to perform arithmetic or logic operations on the encoded data. Since then, the interest of researchers in the area of (bio-)molecular computing has been growing continuously, taking the discipline well beyond the original idea of using biological molecules as fundamental components of computing devices.

Within molecular computing much work has been done on the study of theoretical models of DNA computation and their properties, such as Tom Head's splicing systems, together with experimental work. Convergences with nanosciences, nanoengineering, synthetic biology have also been explored and exploited.

One of the most significant achievements of molecular computing, for example, has been its contribution to the understanding of self-assembly, which is among the key concepts in nanosciences.

The next step has been the passage from the molecular level to the cellular level. The living cell is perhaps the most outstanding self-organized, hierarchical, adaptable, economic and robust information processing system that we know, and cellular processes such as gene regulatory networks, protein-protein interaction networks, biological transport networks and signalling pathways can be studied from the point of view of information processing. This knowledge will also enable us to harness the cell as a "nano-bot", which can be programmed to carry on specific tasks such as targeted drug delivery, housekeeping of chemical factories and coordination of bio-film scaffolding and self-assembling.

The following contributions on the theme of molecular and cellular computing describe some of the projects carried out in Europe, and can be grouped into three groups:

- The first group of papers mainly concern membrane computing, a new unconventional computing model that abstracts from the structure and functionality of the living cell, illustrating both the theoretical basis of the models introduced as well as applications in various fields. M. Gheorghe gives an overview of the field, then G. Franco and V. Manca describe a research project that aims to synthesize a minimal cell, starting from a model based on membrane systems. The third paper (Agrigoroaiei, Aman and Ciobanu) discusses operational semantics, and the notions of causality and mobility in membrane systems. Possible connections with quantum computing are discussed by Leporati. The next paper describes the goals and activities of a Spanish network on Biomolecular and Biocellular Computing, which is not limited to membrane systems, but includes networks of bioinspired processors, synthetic biology, computational biology and bioinformatics. The last paper in this group (Csuhaj-Varjú and Vaszil) is of a theoretical nature, and relates membrane systems to automata, focusing in particular on the distributed organization of components of living systems.

- The papers in the following group focus on biological information processing, based on chemical reactions (Hinze, Bodenstein, Heiland, and Schuster), the engineering of biological systems with a given behaviour (Arroyo, Gómez and Marijuán), and molecular information processors (Gruenert, Dittrich and Zauner). Chemical reactions and the robustness of living systems with respect to the possible failure of their components are the inspiration for architectural ideas for robust distributed systems (Mauri and Petre), middleware (Pazat, Priol and Tedeschi), self-adapting systems (Cuesta, Pérez-Sotelo and Ossowski), and services (Di Napoli, Giordano and Németh).

- Finally, the two closing papers describe projects for the development of a computing device based on bacterial colonies (Amos and the BACTOCOM consortium) and for modelling and simulating biosensors, with possible applications to nanomedicine.

Please contact:
Giancarlo Mauri
University of Milano-Bicocca
E-mail: mauri@disco.unimib.it

Quantum Information and the Emergence of Quantum Engineering

by Thomas Busch

New technologies require new thinking and new materials.

Progress in micro- and nanotechnologies has been a key element in the highly successful quest to satisfy the need for evermore powerful information processing and communication devices during the last decades. This route of progress, however, has a principle limit as smaller structures are necessarily made from fewer and fewer particles and industry is rapidly progressing towards a regime wherein transistors will be made from only a single electron. One can easily see that achieving this goal will lead to a fundamental barrier: due to the indivisibility of electrons the current miniaturisation processes will have reached their final step and new ideas and technologies for enhancing computational power will have to be developed. At the same time, reaching this barrier will also require to develop a completely new set of engineering techniques, since single particles do no longer behave according to the laws of classical mechanics, but instead have to be described quantum mechanically.

As a result, researching the physics of single particles on the quantum scale is of significant importance and has, in recent years, led to a wealth of knowledge and technologies that have underpinned and revolutionised our fundamental understanding of the world. A particularly successful approach has been the application of concepts of information theory to the theory of quantum mechanics, which has led to the development of so-called quantum information devices. The existence of additional resources, such as entanglement, in the quantum regime means that these new devices can have superior qualities to classical devices and solve problems for which no classical algorithms are known. The theoretical work on these issues has been accompanied by tremendous progress in experimental possibilities, and controlled coherent evolution and high fidelity measurements of single particles are, by today, feasible in several synthetic quantum systems. The area is, however, still in its infancy and the development of new ideas for quantum engineering techniques is of large importance for future advances in information and communication technologies. While quantum devices initially only seemed unavoidable, they have turned out to be a highly desirable part of the technological landscape of the future.

Isolating single quantum particles in such a way that they can be deterministically engineered is a very difficult task, due to the often unavoidable environmental interactions or thermal noise. Identifying appropriate systems is, therefore, of large importance and currently a very active strand of research is to test and characterise different candidates for their suitability. One area in which systems that satisfy the basic conditions of good isolations, low noise and high controllability can be found is the area of ultracold atoms and various experimental systems have been build in recent years that allow one to simulate Hamiltonians of importance in quantum information. However, many other systems, ranging from man-made quantum dots in solid state devices to exotic low-dimensional electronic structures are under heavy investigation as well.

Two groups at University College Cork, one experimental and one theoretical, work in this area using ultracold atomic systems. One of their aims is to explore different methods to build interfaces that connect the quantum mechanical world of single atoms to our macroscopic one. A promising method for this is to guide light to the ultracold atom using an optical fibre, have it interact with the atom, and guide is back to the detector. For this we are using a commercial-grade optical fibre, which in the interaction region is stretched to a diameter smaller than 1 micro-meter. The light then no longer fits into the fibre and instead travels on the outside, where it can be accessed by the ultracold atoms. While this technology is still in its infancy, the large flexibility of such a setup makes it a very promising tool for future developments.

The basic entity in a quantum computer is, just as in a classical computer, the bit, now called a quantum bit or qubit. However, while classically a bit can only have two possible states, 0 and 1, a quantum bit can be in any possible combination of these two at the same time. This allows for a powerful parallelism in the computational process, which can be helpful in speeding up algorithms. One common example is the database search, in which one piece of information has to be identified among a large number of elements: instead of sequentially looking at each entry of the database, as required classically, quantum mechanics allows to look at all elements in one operation.

While a full scale quantum computer might still be a long way off, by today almost all fundamental entities and processes have been demonstrated. In fact, first devices using quantum technologies, such as cryptographic systems and random number generators, are already commercially available. Research has started on scaling up the number of quantum bits to carry out more complex processes, as well as improving the stability of the individual qubits. This has helped to significantly increase our understanding of two of the basic properties of quantum mechanics, coherence and entanglement, and is leading the way to explore more complex systems and technologies in the future. Since we are only at the beginning of this journey, the future is likely to hold many unexpected surprises.

Please contact:
Thomas Busch
Department of Physics
University College Cork
E-mail: thbusch@phys.ucc.ie

Topological Quantum Computation: The Quantum Knot in the Handkerchief

by Joost Slingerland

Future quantum computers may use exotic materials which host entirely new types of physical particle, called anyons. Computations in such Topological Quantum Computers would be done by exchanging the anyons, creating 'quantum knots' in the process. This idea has spawned an international effort encompassing pure mathematicians, theoretical and experimental physicists and material scientists. The first electronic devices which are supposed to detect and manipulate anyons have recently been constructed in two-dimensional electron systems, with promising results.

Quantum computers of sufficient size and reliability would not only cause a revolution in data security, but should have many more exciting applications, such as the design of special materials and chemicals. Nevertheless, progress in the fabrication of quantum computers has been slow because in most approaches to quantum information processing, the quantum systems employed to store and manipulate information are very sensitive to noise, either from the environment or due to small errors in controlling the computer's components. This causes these computers to effectively lose their memory - we say there is decoherence of the stored quantum information. Quantum error correction software can in principle solve this problem, but this requires much more reliable basic components than those currently available.

Topological quantum computation (TQC) aims to eliminates decoherence at the hardware level, by encoding quantum information in non-local properties of a suitable quantum system, which cannot easily be disturbed by noise - this is somewhat analogous to the old memory aid of knotting a handkerchief. The information storage and manipulation in topological quantum computers makes use of anyons. Anyons are particles which have the property that the quantum state of the system transforms in a non-trivial way when one of these particles encircles another. As the anyons move around, encircling one another in different ways, their 'world-lines' become tangled up and form knots. To visualize this, we can think of each anyon as connected to a thread and these threads forming a braid as the anyons at their ends are moved around (figure 1). Systems with sufficiently interesting anyons can reliably store a number of qubits which grows linearly with the number of anyons. The

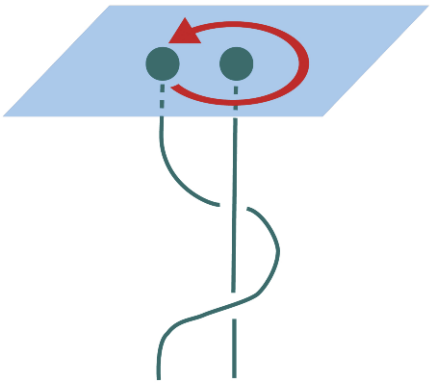


Figure 1: Two anyons in a plane. One encircles the other and the figure shows the braid corresponding to that process.

quantum states which make up the qubits can be obtained from some initial state, and also manipulated further for calculation, by 'braiding' the anyons in different ways. Crucially, as long as the temperature is low enough and the anyons are kept well-separated, there is essentially no other way to disturb the stored information, which makes this computation scheme extremely stable against decoherence.

Anyons can only exist in systems which are effectively two-dimensional, that is, they live in a single plane. Important examples of such systems are two-dimensional electron gases (2DEGs) which can be created on the interfaces between various semiconducting materials, and graphene, a two-dimensional form of carbon which recently earned Andre Geim and Konstantin Novoselov the 2010 Nobel Prize in physics. The most advanced experiments on anyons to date employ 2DEGs at very low temperatures and very strong magnetic fields. Under these conditions the fractional quantum Hall effect occurs - the electrons form incompressible liquids and the smallest possible holes (2D 'bubbles') in some of these liquids are expected to be anyons useful for quantum computation. To experimentally establish the statistics properties of these holes is non-trivial, precisely because these properties are impervious to local probing.

Groups in Maynooth and in the wider Dublin area work on many aspects of planar physics and its application to TQC:

- general mathematical underpinnings of the theory of anyons
- construction and study of exactly solvable microscopic models in which anyons emerge

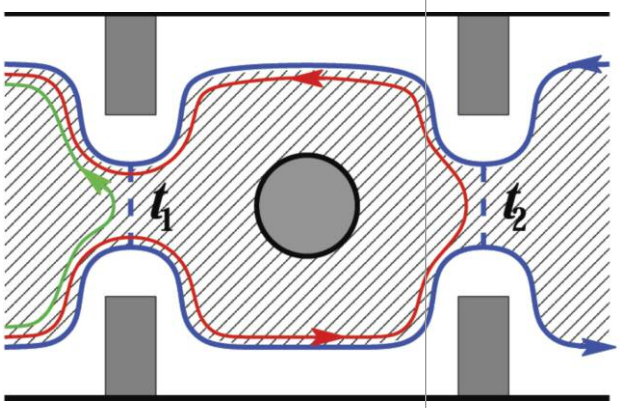


Figure 2: Schematic of a double point contact interferometer, a way to detect and manipulate anyons.

- numerical study of realistic models, for example for fractional Quantum Hall systems
- interpretations and predictions for concrete experiments.

An important line of research has focused on interferometers like the one pictured in figure 2.
Teams of experimental physicists at Bell labs, Princeton, Harvard, the University of Chicago and the Weizmann Institute have already constructed devices similar to this, and promising evidence for the existence of non-Abelian anyons has been emerging. Microsoft has also poured significant scientific and financial resources into this line of research through its TQC research station, 'Microsoft Station Q'.

The figure shows electric current carried by anyons, flowing along the edges of a 2DEG in the fractional quantum Hall regime (seen from above). In two places, the edges are pushed together using contacts shown as gray rectangles. At these two point contacts, anyons can quantum tunnel from the bottom edge to the top. Current which flows from the bottom to the top thus comes from a quantum superposition of amplitudes to take either the green or the red path. This causes oscillations in the current when the size of the region enclosed by the paths is varied. The gray disc in the figure represents a contact which may be used to vary the number of anyons inside the interferometer. The number of anyons inside the interferometric region can dramatically affect the current; in the very simplest model, the presence of an odd number of anyons makes the current oscillations disappear completely, while an even number of anyons has no such effect. Observing these two behaviors in the same system would be a dramatic signature of the presence of non-Abelian anyons (the kind of anyons needed for TQC). Devices such as this are likely to provide the first smoking gun detection non-Abelian anyons, and also provide an important tool in manipulating the state of future anyonic quantum computers.

Links:
http://www.thphys.nuim.ie/daqist/
http://www.thphys.nuim.ie/staff/joost/PI/intro.html
http://stationq.ucsb.edu/

Please contact:
Joost Slingerland
Department of Mathematical Physics
National University of Ireland
Maynooth
E-mail: joost@thphys.nuim.ie

Algorithms via Quantum Random Walks

by Michael Mc Gettrick

We are working on features displayed by a number of new scenarios in Quantum Random Walks (QRW).It is expected that many features of QRWs (eg hitting time, localization) will be useful in developing quantum algorithms. Amongst other topics, we look at "memory effects" in walks, simulating a 2-dimensional walk with a 2-state coin, and quantum fairness in lazy QRWs.

In classical Markov models, one of the ways of extending the system is to take in to account the "history" of the previously occupied states. The simplest extension (looking "back" one step) has been studied by us in the corresponding QRW. We get different probability distributions compared to the QRW without history (or, as we call it, memory). In particular, for certain initial states of the Quantum Walker, the phenomenon of localization is observed at the origin: In this case, even after an infinite number of steps, the probability of finding the walker at the origin is greater than 50%. This does not happen in either "standard" QRWs or indeed in classical random walks. The techniques we employ are both rigorous mathematical calculation, and simulation by "running" a finite number of steps of the walk on a computer. We have found the simulation often suggests features of the walk that we can then try and prove. This work is all carried out in the De Brun Centre for Computational Algebra at the National University of Ireland, Galway.

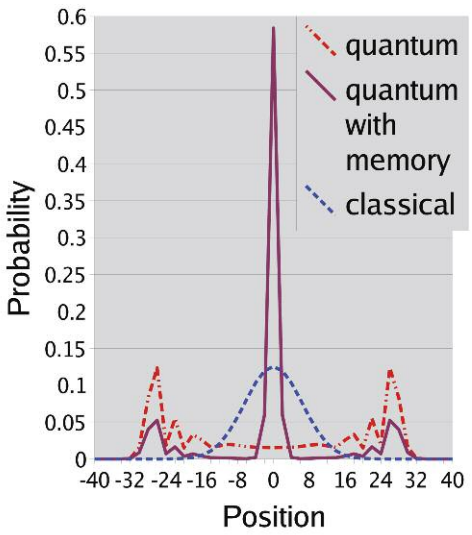


Figure 1: A plot of the probability distributions in a Quantum Random Walk with memory on the straight line (purple). For comparison, the classical walk (blue) and Quantum Walk without memory (red) are also shown. The number of steps in this walk is 40. The walk with memory shows the feature of localization, with over 50% of the probability at the origin.

In a further project, we look at QRW with memory on the Cayley Graph of an Abelian Group. This is collaboration with Claas Roever (Galway), Mike Batty (Durham) and Jaroslaw Miszczak (Polish Academy of Sciences). We have had some successes here with analysing the simple case of the QWR on a cycle (which is a Cayley Graph of the cyclic group). When we add one step memory to this, it becomes a QRW on a Cayley

Graph of the Dihedral Group. The aim is now to understand the general picture of re-writing a QRW with memory as one without memory on a different graph. One of the reasons we carry this out is we believe putting in memory in to the process gives us a type of control over the probabilistic outcomes that could be useful in directing algorithms.

Work in collaboration with Carlo Di Franco and Thomas Busch at University College Cork has focused on how we can decrease the resources needed to construct QRWs in 2 dimensions. Taking the typical square lattice as an example, we have successfully constructed the Grover Walk without using a "2 dimensional coin". Our walk uses simply a 2-state coin, but alternates the moves up/down and left/right to get 2-dimensional behaviour. The Grover walk comes from the same ideas as used in the famour Grover Algorithm for searching an unordered list. Because our walk uses a lower dimensional coin, we expect it to be easier to implement in a physical scenario. We hope soon to be able to extend the idea of an alternating walk to other models.

Finally, along with research students David Dolphin and Aine Ni Dhonnacha at NUI, Galway, we have looked at the idea of Lazy QRWs, and have phenomenological results in this area. Our idea has been to use the 3 state qutrit to model the 3 possibilities in a lazy QRW (move left, move right, stay put). A further online quantum walk simulator has been built (see URLs at the end) to simulate QRWs on the cycle.

Links:
http://www.maths.nuigalway.ie/~gettrick/research/
http://walk.to/quantum

Please contact:
Michael Mc Gettrick
National University of Ireland, Galway
E-mail:
michael.mcgettrick@nuigalway.ie

Unentangled Quantum Proofs and their Applications

by Ashley Montanaro

Entanglement is a key resource for quantum computers. However, the lack of entanglement can also be a powerful concept in quantum computation.

The unintuitive features of quantum mechanics have delighted and confounded physicists in equal measure for over a century. A central aspect of quantum theory is the super-strong quantum correlation known as entanglement. This "spooky action at a distance" enables many of the most well-known and surprising examples of quantum effects, such as quantum teleportation, and is considered to be an essential component of the exponential speed-ups that can be achieved by quantum computers over standard ("classical") computers. However, recent work at the Centre for Quantum Information and Foundations at the University of Cambridge, in collaboration with the University of Washington, has shown that the absence of entanglement can also lead to significant computational advantages.

This work takes place in the setting of so-called quantum Merlin-Arthur games. In this framework, a prover (Merlin) sends a computationally limited verifier (Arthur) a quantum state, which Arthur uses as a resource ("proof") to enable him to solve a computationally challenging problem. We think of Merlin as being all-powerful, but not to be trusted: Arthur must check the proof to ensure that Merlin does not trick him into answering incorrectly. This is a model for problems which cannot necessarily be solved efficiently, but whose solutions can be verified efficiently by a quantum computer. Many natural problems in quantum physics turn out to fall into this category.

A natural generalisation of this framework is to give Arthur access to more than one prover, but to separate the provers and not to allow them to communicate. If Arthur receives two or more unentangled quantum states as proofs, he might be able to use them to solve problems which he could not solve with access to just one quantum state. The reason for this is that Arthur may be able to validate the proofs against each other to check for errors or malicious modifications by the provers. By contrast with the classical setting, where multiple proofs can simply be concatenated together, the fact that sep-

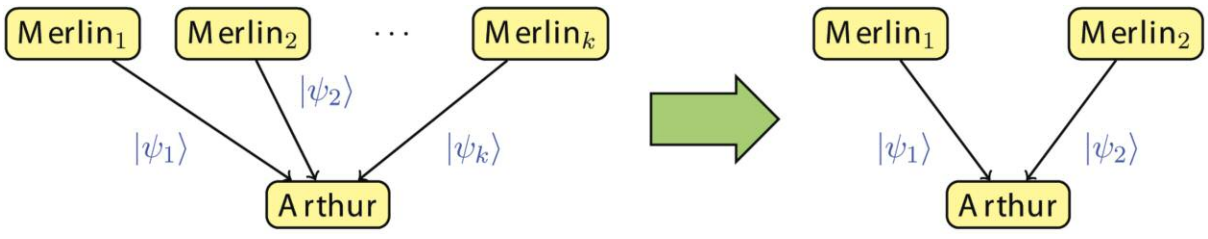


Figure 1: Multiple unentangled quantum proofs can be simulated by only two proofs.

arate quantum proofs are unentangled is crucial to enable this cross-checking.

Our work centres on the notoriously hard boolean satisfiability problem 3-SAT, for which no classical (or indeed quantum) algorithms are known that run in time subexponential in the length of the input. Surprisingly, we show that 3-SAT can in fact be solved efficiently by a quantum computer, as long as it is given access to two unentangled proofs, the length of each of which is approximately the square root of the size of the input. As classical computers appear to require proofs approximately as long as the original input to solve 3-SAT efficiently, this implies a significant quantum advantage.

It was previously known that 3-SAT can be solved efficiently, given access to a large number of unentangled quantum proofs. In order to use this prior work to prove our new result, we develop and analyse an efficient quantum algorithm that certifies that the state of a large number of quantum systems is unentangled, given only two copies of the quantum state to be tested. This result then allows Arthur, given two unentangled proofs, to simulate multiple unentangled proofs, and to use the previously known protocol to solve 3-SAT.

On the flip side, our result implies obstructions to classical simulation of two-prover unentangled quantum proof systems. If such systems could be efficiently simulated classically, this would imply classical algorithms for 3-SAT that run in less than exponential time, which are considered very unlikely to exist. It turns out that these proof systems are connected to many central tasks in quantum information theory. For example, our work implies computational hardness of estimating the capacity of quantum communication channels, detecting bipartite entanglement, and estimating ground-state energies of certain classes of quantum system. Thus the apparently arcane framework of quantum proof systems with multiple unentangled provers is in fact closely related to other aspects of quantum information theory, and is even connected to optimisation problems from outside the field.

While entanglement is seen as the basis of quantum computational power, our work implies that the absence of entanglement can also be desirable. Future work aims to determine the precise computational power of multiple quantum proofs, and also to investigate intriguing connections to the power of entanglement in quantum information transmission.

Link:
http://arxiv.org/abs/1001.0017

Please contact:
Ashley Montanaro,
Centre for Quantum Information and Foundations, Centre for Mathematical Sciences, Cambridge
Tel: +44 1223 760383
E- mail: am994@cam.ac.uk

Position-Based Quantum Cryptography

by Harry Buhrman, Serge Fehr and Christian Schaffner

Position-based cryptography offers new cryptographic methods ensuring that certain tasks can only be performed at a particular geographical position. For example, a country could send a message in such a way that it can only be deciphered at the location of its embassy in another country. Using classical communication, such tasks are impossible to perform. At CWI, we investigate whether position-based cryptography can be achieved if players are allowed to use quantum communication.

Quantum cryptography makes use of the quantum-mechanical behavior of nature for the design and analysis of cryptographic schemes. Its aim is to design cryptographic schemes whose security is guaranteed solely by the laws of nature. This is in sharp contrast to most standard cryptographic schemes, which in principle, can be broken, i.e., when given sufficient computing power. From a theoretical point of view, quantum cryptography offers a beautiful interplay between the mathematics of adversarial behaviour and quantum information theory.

The best-known application of quantum cryptography is quantum key distribution (QKD). QKD allows two distant parties to securely communicate in a way that cannot be eavesdropped on. The technical requirements to perform QKD protocols are well within reach of today's technology; in fact, QKD devices are currently produced and sold commercially. QKD requires the two involved parties to know and trust each other. In general, however, cryptography is concerned with scenarios where the involved parties want to exchange data without trusting each other. In order to distinguish themselves from an attacker, legitimate players commonly use some form of credential, for example, a digital secret key or biometric data such as a fingerprint. The goal of position-based cryptography is to let the geographical position of a person act as its only credential for accessing secured data and services. This has the important advantage that no digital keys need to be distributed and locally stored, which is often the bottleneck in standard cryptographic solutions and offers opportunities for attacks.

Position-based cryptography has a number of interesting applications. For example, it enables secure communication over an insecure channel without having any pre-shared key, with the guarantee that only a party at a specific location can learn the content of the conversation; think of a military commander who wants to communicate with a base which is surrounded by enemy territory, or a country that wants to send instructions to an embassy in a foreign country. Another application is authenticity verification, where position-based cryptography enables users to verify that a received message originates from a particular geographical position and was not modified during the transmission.

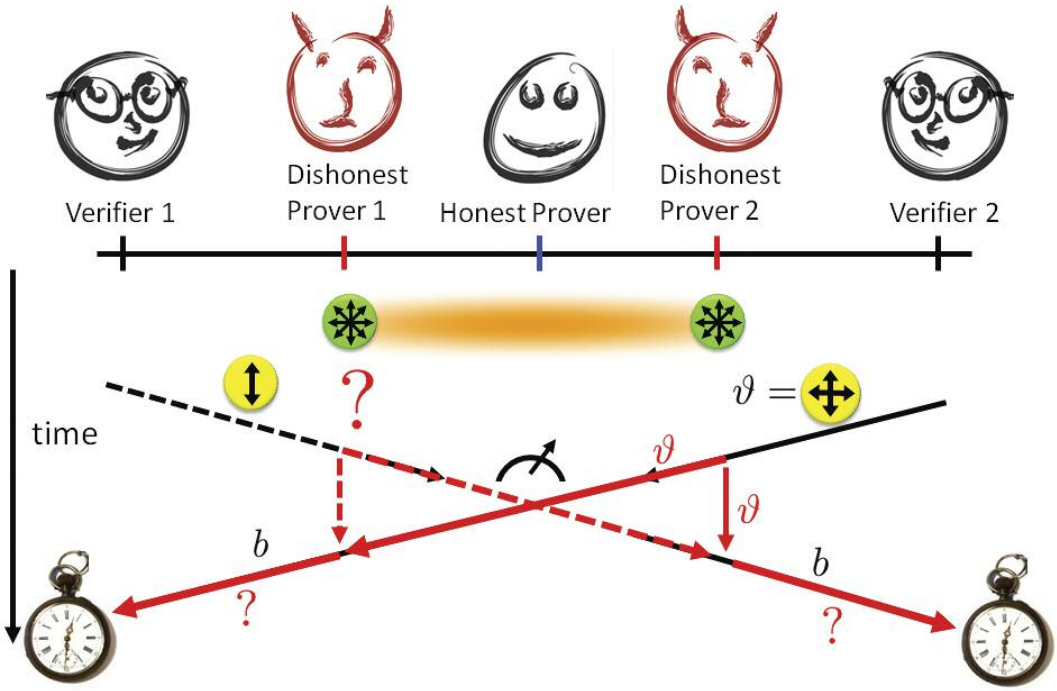


Figure 1: Quantum protocol for position verification in one dimension. (Picture by C. Schaffner with images from Svilen Milev and Victor Zuydweg.)

In 2009, it was proven by our collaborators from the University of California in Los Angeles (UCLA) that position-based cryptography is impossible in the classical (non-quantum) world in the setting where colluding opponents control the whole space which is not occupied by honest players. In our latest research article, we investigate whether the impossibility of position-based cryptography can be overcome if we allow the players to use quantum communication.

The outcome of our theoretical investigation demonstrates that the possibility of doing secure position-based cryptography depends on the opponents' capability of sharing entangled quantum states. On the one hand, we show that if the opponents cannot share any entangled quantum state, then secure position-based cryptography is possible. We present a scheme which allows a player, Alice, to convince the other participants in the protocol that she is at a particular geographical position. In contrast, colluding opponents who are not at this position and do not share any entangled quantum state will be detected lying if they claim to be there. Our scheme is very simple and can be implemented with today's QKD hardware. More advanced applications (as outlined above) can be based on our scheme.

On the other hand, we also show that if the opponents are able to share a huge entangled quantum state, then any positioning scheme can be broken and no position-based cryptography is possible at all. In fact, our result shows how colluding opponents can use their entangled state to instantaneously and non-locally perform the honest player's operations and are therefore able to make it appear as if they were at the claimed position.

Our results raise various interesting research questions. For example, it is a formidable technical challenge to store and handle large quantum states. Hence, is secure position-based cryptography possible in the realistic setting where opponents can only handle a limited amount of entangled quantum states? Our investigation has already sparked several follow-up works and first results indicate that there are schemes which remain secure in this bounded-entanglement setting.

Link:
http://homepages.cwi.nl/~schaffne/positionbasedqcrypto.php

Please contact:
Christian Schaffner
CWI Amsterdam, Netherlands
Tel: +31 20 592 4236
E-mail: c.schaffner@cwi.nl

High-Speed Quantum Key Distribution and Beyond

by Martin Stierle and Christoph Pacher

The design and implementation of mature entanglement based systems as well as developing the software for setting up the largest quantum network in Europe is the hallmark of the Quantum Key Distribution developments at the AIT Austrian Institute of Technology

Quantum Key Distribution (QKD) uses the properties of individual particles of light (photons) to establish a digital key between two communication partners. Based on the principles of quantum physics the information carried by a photon cannot be extracted unnoticed by the legitimate partners as any extraction of information requires a measurement that modifies the properties of the photon. Additionally, the principles of quantum physics dictate that an identical photon cannot be produced by an eavesdropper. Therefore, any attempt to intercept will be detected by both parties and it is proven that the distribution of digital keys is absolutely secure (ie Information Theoretic Secure (ITS)) against eavesdropping. Consequently messages encrypted with these keys using One-Time Pad encryption can withstand any attacks from arbitrary powerful computers (and even Quantum Computers). In addition secret keys generated with QKD can be used for ITS message authentication. Thus QKD gives us a tool for absolutely secure communication within the digital world.

How QKD technology evolved - a bit of history

In 1984, Charles Bennett and Gilles Brassard proposed the use of quantum communication for cryptographic purposes. Over the following years it was proven that even an adversary with unlimited computing resources cannot break quantum key distribution , something that cannot be realized with classical means alone. The technology of current products corresponds to the status of development of 2000-2003. These products are usually operated in point to point connections and have strong restrictions on the key generation rate and distance.

Meanwhile research groups around the world are working on a second generation of QKD link devices and new laboratory prototypes have emerged. These belong to a variety of different classes of systems, the common denominator being that the key generation rate and distance perform much better. Briefly, the second generation systems include:

- discrete variable systems, based on weak coherent pulses and decoy states
- discrete variable systems, based on quantum entanglement
- continuous variable systems and
- distributed phase reference systems.

The AIT Austrian Institute of Technology has designed and implemented mature entanglement based systems as well as developed the software for setting up the largest quantum network (six nodes and eight links) in Europe so far.

Both, the AIT link systems as well as the SECOQC (Development of a Global Network for Secure Communication based on Quantum Cryptography) net-

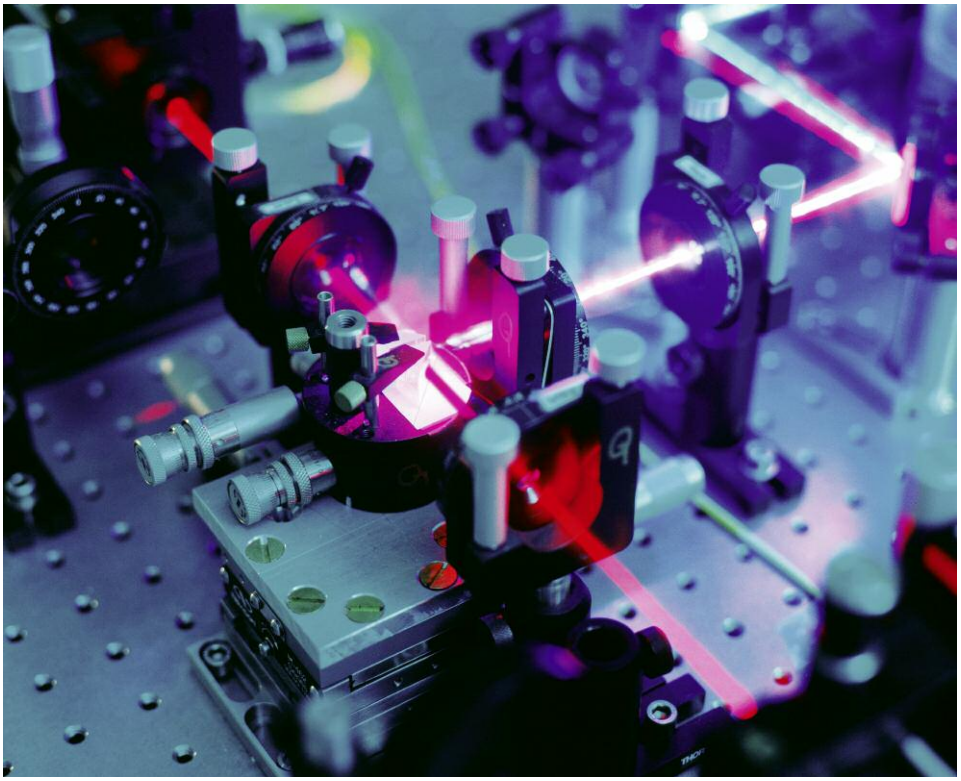


Figure1: entangled photon source.

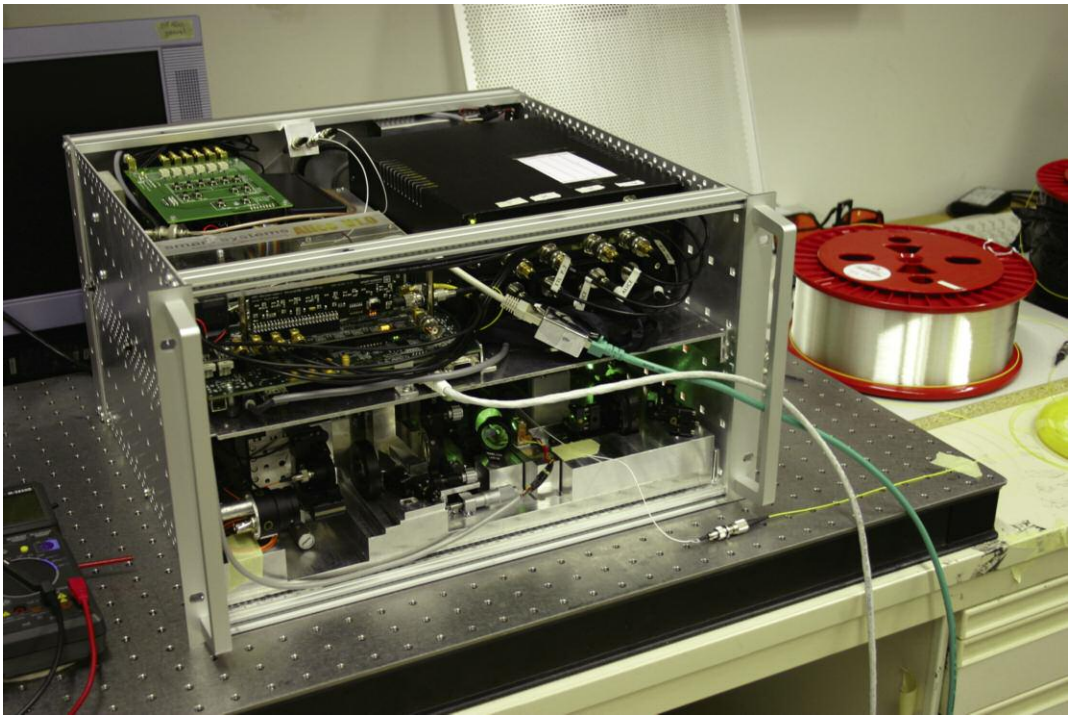


Figure 2: Entangled photon QKD device prototype.

work were developed during the European 6th Framework Programme, and were deployed in Vienna in 2008. Research and development were carried out in cooperation with Prof. Zeilinger's group at the Institute of Experimental Physics, University of Vienna and IQOQI of the Austrian Academy of Sciences. Recent research results (related to finite key analysis) demonstrate that the system is particularly suitable for long-haul communication as a consequence of its ability to generate a secure key even out of a small sample of measured signals.

QKD - the research agenda!

Even with telecom's recent switch from copper to fibre – and fibre is a prerequisite for single photon communication – QKD is far from entering our everyday life. However, the worldwide research and development agenda is straightforward. What QKD needs for better market acceptance are:

- longer distances
- reduced cost per unit especially in the access to the private customer market
- integration into the telecom world and respective standardization, and
- satellite key distribution to overcome trans-continental distance restrictions.

Austrian Institute of Technology – our approach

Based on our assessment of the key factors required for a real market acceptance, AIT is concentrating on the development of two specific QKD link systems. The first one will be a backbone QKD link system which can be used in parallel with the telecom´s DWDM (Dense Wavelength Division Multiplex) networks. We expect the new system to operate over a distance of 150km and to push the metropolitan range key generation rate up to a range between 300 Mb/s to 1 Gb/s.

The second QKD link system will be a low-cost, low key generation rate PON (Passive Optical Network) system. In this project a one-to-many quantum communication concept instead of point to point concepts will be implemented in order to reduce costs significantly.

In addition, AIT is chairing the ETSI Industry Specification Group on Quantum Key Distribution. AIT also is involved in some analysis on QKD satellite systems. They will be needed to overcome distance restrictions, especially with respect to intercontinental key distribution.

How might the future look? The quantum communication world!

Not only military, but also civil applications are in use. Whenever you want secure and private communication, even over long time periods, you might use QKD and new ways of encryption. This will be true for banks and governments as well as all the e-health community.

Telecom exchanges will work as trusted repeater stations and form the backbone of the key distribution infrastructure. PONs will extend the reach to the private customers, eg medical doctors. Thus, quantum channel networks will be offered like VPNs. In addition to these more local structures, WWKE – worldwide key exchange will be offered by one or more wholesale key exchange satellite or telecom operators.

Links:

http://www.ait.ac.at/departments/safety-security/business-units/optical-quantum-technology/

https://sqt.ait.ac.at/software/
https://sqt.ait.ac.at/ HiPANQ
http://bit.ly/LQuNet
http://truq.at (only in German)

Please contact:
Martin Stierle
Austrian Institute of Technology / AARIT, Austria
Tel.: +43 664 235 1847
E-mail: martin.stierle@ait.ac.at

Membrane Computing – Theory and Applications

by Marian Gheorghe

Membrane computing is a new unconventional computing model that abstracts from the structure and functionality of the living cell. Developments of this computational paradigm cover both the study of the theoretical basis of the models introduced as well as applications in various fields.

It might appear that at the moment, the interaction between computer science and biology is intensifying, with positive consequences for both fields. Biology has been seen as a rich source of ideas for creating novel approaches, methods, algorithms and techniques for solving complex computational problems, for generating new concepts and theories that help specify and analyse various systems and for providing a new basis for the theory of computation itself. On the other hand, complex and sophisticated computer science approaches have been utilized in modelling various biological systems, by providing a rich set of methods and techniques to specify and analyse such systems.

Membrane computing had emerged as a branch of natural computing by the end of the 1990s. The models belonging to this computational paradigm, called membrane (or P) systems, have been conceived as hierarchically distributed devices inspired by the structure of living cells. Some of these models have also been abstracted from the structure and functionality of more complex biological entities, like tissues, organs and populations of cells. Membrane computing started off as a new unconventional computational paradigm generating a broad range of fundamental research in theoretical computer science. In recent years, membrane systems have been used as modelling vehicles for various biological systems or as specification languages in graphics or for describing a large variety of parallel and concurrent systems. For a comprehensive presentation of this research field, The Oxford Handbook of Membrane Computing (see link 1) is recommended, and for an almost exhaustive list of publications in this field, the website available at link 2 can be consulted. The above mentioned lines of research have been followed by our group at the University of Sheffield as well.

We have been working on developing various types of membrane systems inspired by phenomena from the world of biology, including: intra- and intercellular signalling mechanisms (captured by P systems with travelling objects); communication processes occurring in populations of cells or more complex organisms (population P systems); and concerted actions of individual entities in populations of bacteria (quorum sensing P systems). As with other types of membrane systems, researchers have investigated various aspects of these models, including their computational capabilities, complexity aspects and relationships with other classes of computational models, including various process algebras, Petri nets, cellular automata, X-machines and grammar systems. Establishing such relationships has allowed us to transfer from these models to membrane systems a rich set of methods and tools to analyse and validate the consistency of such systems.

We have been interested in utilising P systems as specification languages for various natural, artificial or engineered systems. In this respect a specific class of membrane system has been introduced and studied for application in graphics. Another class has been introduced in connection with synchronizing the components of a system running in parallel. Special attention has been paid to systems with stochastic behaviour, especially from biology. For such systems, we have not only introduced a

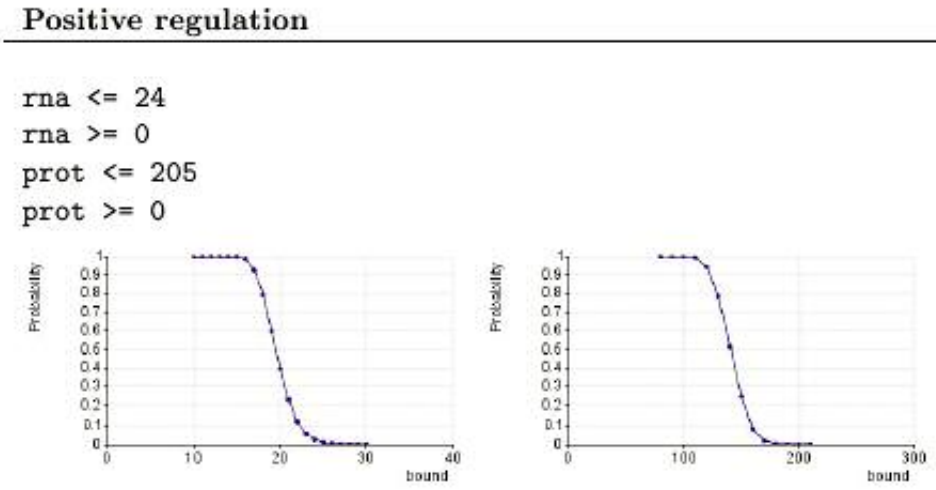


Figure 1: Invariants checking with PRISM.

specification language, but have also produced simulation tools and utilized a number of state-of-the-art tools for system analysis.. The power and effectiveness of stochastic simulators have been complemented by a fine-grain analysis of various properties of the systems simulated by using a tool called Daikon (see link 3). These properties extracted from simulations have been then validated through verification techniques using PRISM, a probabilistic model checker (see link 4 and Figure 1). More details regarding these applications can be found at the link.

We are actively cooperating with many of the research groups working in membrane computing. We have been working with the group at the University of Verona (Vincenzo Manca) on the dynamical properties of P systems, with the group at the Universities of Paris XII (Sergey Verlan) and Metz (Maurice Margenstern) on synchronization problems in membrane systems, with Erzsebet Csuhaj-Varju and Gyorgy Vaszil at the Computer and Automation Institute of the Hungarian Academy of Sciences on membrane systems inspired by social networks, with Natalio Krasnogor at the University of Nottingham on using membrane systems as a modelling tool in synthetic biology, with Mario Perez-Jimenez and his group at the University of Seville on developing adequate tools for simulating membrane systems, with Giancarlo Mauri at the University of Milan-Bicocca on classes of system with stochastic behaviour. Further research plans for our group include the development of some programmability capabilities for these systems associated with sound verification and testing methods.

Links:
1. http://ukcatalogue.oup.com/product/9780199556670.do
2. http://ppage.psystems.eu/
3.http://groups.csail.mit.edu/pag/daikon/download/doc/daikon_manual_html/daikon_8.html
4. http://www.prismmodelchecker.org/
5. http://staffwww.dcs.shef.ac.uk/people/M.Gheorghe/

Please contact:
Marian Gheorghe
Department of Computer Science
University of Sheffield, United Kingdom
Tel: +44 114 222 1843
E-mail: m.gheorghe@dcs.shef.ac.uk

On Synthesizing Replicating Metabolic Systems

by Giuditta Franco and Vincenzo Manca

A research project at the University of Verona concerns the synthesis of a minimal cell by means of a P system, which is a distributed rewriting system inspired by the structure and function of the biological cell. We aim to define a dynamical system which exhibits a steady metabolic evolution, resulting in self-maintenance and self-reproduction. Metabolic P Systems, shortly called MP systems, represent a specific class of P systems which is particularly promising to model a minimal cell in discrete terms

The idea of synthesizing a 'minimal cell' by mathematical and engineered tools is not new in the literature, namely there is a recent trend in synthetic biology towards building a synthetic endomembrane structure, whose compartments (usually formed by liposomes) contain the minimal components required to perform the basic function of a biological cell (essentially self-maintenance and self-reproduction). A self-replicating metabolic system requires a synchronization of its internal dynamics in such a way that the metabolic activity is maintained, while the system exchanges matter with the environment, grows, and replicates its own membrane structure together with the contained metabolic processes. We aim to model such a dynamical system by using a P system; a computational model inspired by the cell.

This research may be framed within the context of membrane computing models, an area of molecular and cellular computing, and aims to build a self-replicating metabolic membrane system where molecular and cellular peculiarities are represented in symbolic and algorithmic terms. It was started at the beginning of the 2011, and its purpose is to develop an understanding of the general rules governing the synchronization of genomic duplication and membrane reproduction. This is known as a "top-down" approach to synthesize minimal forms of life starting from general principles of structure and function organization (matter conservation, anabolism and catabolism, species distribution, enzymatic control, autopoiesis). In principle, this approach has an experimental counterpart, and it can be classified as a constructivist approach for scientific knowledge, according to Feynman's famous motto "What I cannot create, I do not understand".

The techniques employed in this project are a combination of membrane computing and metabolic P systems, statistical regression and correlation methods, numerical approximation and time series analysis techniques. The research is intended to have a mathematical/symbolical – computational orientation, and the main expected product is a Metabolic P model of a minimal cell. The research project will be conducted at the department of Computer Science of the University of Verona, and there are involved both the authors together with some members of the MNC group

Regarding future activities of this research, we have plenty of ideas and dreams; we are limited only by our imagination. Once we have a self-replicating MP system which exchanges matter with the environment to maintain its internal metabolic dynamics, both the role of energy in such an exchange and a form of adaption to the environment could be studied, by analyzing the consequent reactions of the system to different (even energetic) stimuli. Receptivity and reactivity should be

investigated to better understand the robustness of the single cell and of cell networks. Communication and interaction among (synthetic and/or real) cells is a crucial task to model morphogenesis (e.g., embryogenesis) and tissue organization. From the viewpoint of a tissue system, the process of mitosis of each single cell is limited in time; single healthy cells do not live forever but tissues do, while new cells rise and old ones die. Tissues stay alive under certain boundaries (density, dimension), while single cells produce new cells and eventually die. The cellular and tissue systems are tightly interrelated but have quite different dynamics and function.

The study of phenomena such as cell differentiation and speciation are fundamental for the understanding of many processes of biomedical interest. For example, embryonic cells are interesting as they have illimitable replicative power and the ability to generate any type of tissue, a property they have in common with stem cells. On the other hand, non-controlled proliferation and differentiation of stem cells often denote presence of cancer. Cell migration can also be involved in such processes, and through our research we expect to find a way to represent both molecular and cellular migration in the context of P systems. In this framework a sensible place to start is by modelling the concept of the biological gradient, which might be achieved by means of nested membrane localization. Finally, cell Darwinian (and other) evolution of synthetic cells could give interesting insights on several controversial issues in population genetics evolution theories (such as the importance of the chance in evolutional transformations, known as genetic drift).

Research group at the University of Verona.

Other institutes involved in this research project are the partners in a recent European FET-project called Minie (MINImal Eukaryotic cells), now under valuation: the "Politecnica" and the "Complutense" University of Madrid, and the University of Zaragoza, all in Spain, the University of Milano Bicocca, Italy, the University of Bucharest, Romania, the University of Leiden, Holland, and the Malardalen University in Sweden.

Please contact:
Giuditta Franco and Vincenzo Manca
University of Verona, Italy
Tel: +39 045 802 7045/7981
E-mail:
giuditta.franco@univr.it,
vincenzo.manca@univr.it

Semantics, Causality and Mobility in Membrane Computing

by Oana Agrigoroaiei, Bogdan Aman and Gabriel Ciobanu

A research group at the Alexandru Ioan Cuza University of Iași, Romania, affiliated to the Romanian Academy of Sciences, conducts research in the area of membrane computing on topics such as operational semantics of the membrane systems, causality, object-based and rule-based event structures, as well as several aspects of mobile membranes including computability, complexity and links to other existing formalisms.

Membrane computing is a well-established and successful research field which belongs to the more general area of natural computing. Membrane computing was initially developed by Gh. Păun in 1998, and in 2003 was identified by Thomson Institute for Scientific Information as a "fast emerging research front in computer science". Membrane computing deals with parallel and non-deterministic computing models inspired by cell biology. Membrane systems are complex hierarchical structures with a flow of materials and information which underlies their functioning, involving parallel application of rules, communication between membranes and membrane dissolution. A "computation" is performed in the following way: starting from an initial structure, the system evolves by applying the rules in a non-deterministic and maximally parallel manner. The maximally parallel way of using the rules means that in each step we apply a maximal multiset of rules, namely a multiset of rules such that no further rule can be added to the multiset. A halting configuration is reached when no rule is applicable.

Operational Semantics

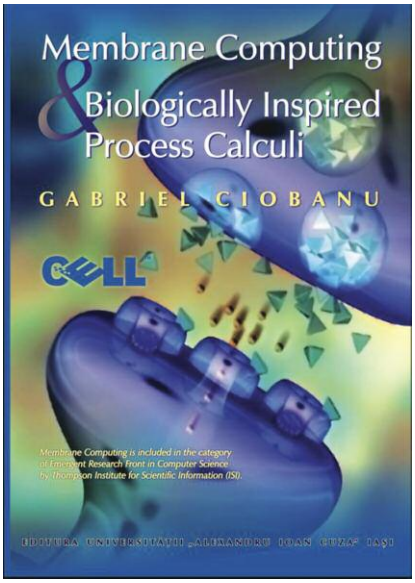
We define the operational semantics for membrane systems, and prove that the semantics for both static and dynamic resource allocation are equivalent. We consider some alternative modes of evolution, based on either minimal parallelism, maximizing the quantities of consumed resources or maximizing the number of applied rules. For systems with a complex hierarchical structure, we present a reduction to a system with a single membrane (and additional rules). Such a reduction is achieved by encoding the semantic constraints of the hierarchical system within rule using promoters and inhibitors in the system consisting of just one membrane. This reduction is subsequently used as a technical tool to solve problems for complex systems by reducing them to simpler cases.

Causality

We construct systems with evolution running in reverse by inverting the direction of the rules themselves. We underline the similarity between the two modes of evolution (direct and reverse), and propose how both of them can be used during computations. We relate membrane systems to event structures by considering events to be related to rule applications (in one case), and to resources (in another case). The corresponding event structures represent formal tools underlying causal relations in the evolution of a parallel and nondeterministic system. We prove that the causal relation given by the resource based event structure is directly related to the way membrane rules can be linked together by a newly introduced causal relation.

Mobility

Mobile Membranes represent a parallel and nondeterministic computing model inspired by cells and their movements in which mobility is given by specific endocytosis and exocytosis rules. We studied the computability power and complexity of mobile membranes, and established some links to process algebra. We have introduced various membrane systems in which mobility is the key issue. The main mobility rules describing the evolution of the structure are endocytosis (moving an elementary membrane inside a neighbouring membrane), and exocytosis (moving an elementary membrane outside the membrane where it is placed); other mobility rules are given by pinocytosis and phagocytosis. We related systems of mobile membranes to some existing process calculi (mobile ambients, pi-calculus, brane calculi) and to Petri nets. We define some concepts inspired from process calculi in the framework of (mobile) membrane computing. To obtain more interesting and accurate models, we add timers inspired by cell lifetime to membranes. We relate these membrane systems with timers to timed mobile ambients. By describing biological systems using mobile membranes, we can provide precise answers to many interesting biological questions. Using software tools and process calculi bisimulations, (potentially infinite) system behaviour can be investigated, and this information could be interesting from a biological viewpoint.



This book presents new ideas and results in membrane computing. The table of contents is avavailble at http://profs.info.uaic.ro/~gabriel/contents.pdf
For more information, please contact the author.

A standard approach in membrane computing is to look for membrane systems with a minimal set of ingredients which are powerful enough to achieve the full computability power of Turing machines. We have investigated the computability power and efficiency of our formalisms by using formal languages, register machines and other ingredients of computability theory. For certain systems of mobile membranes, we prove that it is enough to have three membranes to get the same computational power as a Turing machine. Moreover, using systems of mobile membranes, we got polynomial solutions of two NP-complete problems. More details can be found on our web pages.

Link:
http://iit.iit.tuiasi.ro/TR/

Please contact:
Gabriel Ciobanu
A.I. Cuza University of Iași, Romania
E-mail: gabriel@iit.tuiasi.ro,
gabriel@info.uaic.ro
http://profs.info.uaic.ro/~gabriel/

From Energy-based to Quantum (inspired) P systems

by Alberto Leporati

Taking into account the amount of energy used and/or manipulated during computations may yield formal computational models which are closer to physical reality.

Membrane systems (also known as P systems) were introduced in 1998 by Gheorge Păun as a class of distributed and parallel computing devices, inspired by the structure and function of living cells. The basic model consists of a hierarchical structure composed of several membranes embedded into a main membrane called the skin. Membranes divide the Euclidean space into regions that contain some objects and evolution rules. Using these rules, the objects may evolve and/or move from a region to a neighbouring one. Every computation starts from an initial configuration of the system, in which multisets of objects are scattered among the regions. At each computation step some rules are selected from the pool of active rules, according to a predefined strategy, and are applied; the computation terminates when no evolution rule can be selected. Usually, the result of a computation is the multiset of objects contained in an output membrane or emitted from the skin of the system.

At the Department of Informatics, Systems and Communication (DISCo) of the University of Milano–Bicocca we have been working on P systems since their invention. In particular, we study the computational power of several

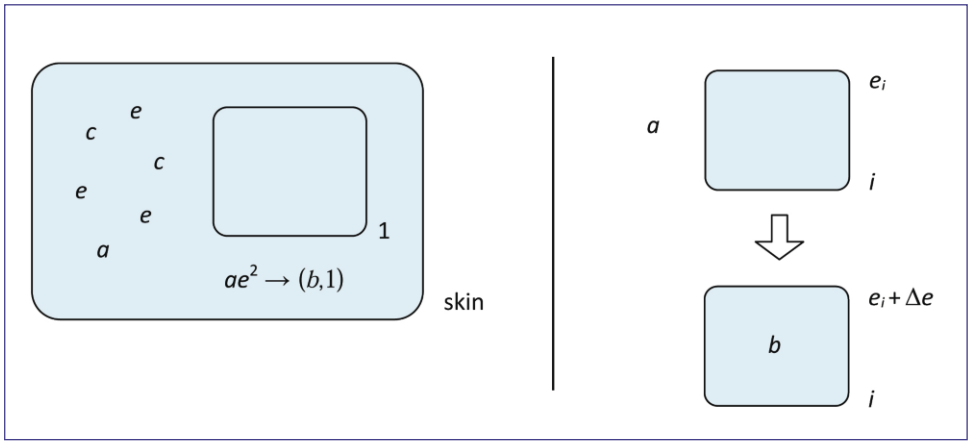


Figure 1: On the left: an example of an energy-based P system. The skin membrane contains one copy of object a, two copies of c and three energy units. The rule $ae^2 \rightarrow (b,1)$ adds two energy units to a copy of a, produces a copy of object b and sends it to the (until now empty) region enclosed by membrane 1. On the right: illustration of the effect of rule $(in_i: a, \Delta e, b)$ on membrane i. The object a crosses the membrane becoming b; simultaneously, the energy assigned to the membrane passes from e_i to $e_i + \Delta e$.

variants of P systems by using techniques from the theory of Computational Complexity. When I joined the group in 2004, I had just completed my Ph.D. in Computer Science with a thesis on complexity issues related to classical and quantum circuits. It was therefore very natural to me to enter the exciting world of P systems by defining two models that take account of the amount of energy exchanged with the environment and/or manipulated during computations: energy-based P systems and UREM (Unit Rules and Energy assigned to Membranes) P systems.

In energy-based P systems, a given amount of energy is associated with each object. Moreover, instances of a special symbol are used to denote free energy units occurring inside the regions of the system. These energy units can be used to move or transform objects, by rules that satisfy the principle of energy conservation. The transformation is performed by taking/releasing an appropriate amount of free energy units from/to the region where the rule is applied. My colleagues and I have studied several computational properties of energy-based P systems, trying to characterize their computational power. We have thus shown that they are able to simulate any reversible and conservative circuit composed of Fredkin gates, and we have proved that they are universal – that is, they have computational power equivalent to that of Turing machines – provided that a form of local priorities is assigned to the rules of the system. Without such priorities, the computational power decreases and is no more than that of Vector Addition Systems. Characterizing the precise computational power of energy-based P systems is still an open problem; however, the results obtained so far indicate that these systems can be used as a modelling tool just like Petri nets.

On the other hand, in UREM P systems a non-negative value of energy is assigned to each membrane. The rules are of two possible kinds: $(in_i: a, \Delta e, b)$ and $(out_i: a, \Delta e, b)$, controlling the objects trying to enter and leave membrane i, respectively. When one of these rules is applied, the object a on which it operates is transformed to b while crossing the membrane; simultaneously, the amount of energy associated with the membrane is changed by adding the quantity Δe, which may be positive, zero or negative. Also these P systems have undergone an extensive study concerning their computational power. In this case by using a form of local priorities we reach the computational power of Turing machines, whereas by avoiding priorities the computational power decreases. This time, however, we obtain a characterization of $PsMAT^{\lambda}$, an interesting class of matrix grammars which is not so easy to obtain with other computational models.

Another interesting aspect of UREM P systems is that they have allowed us to define a quantum-inspired variant of P systems. Instead of merely translating each rule of UREM P systems to a unitary matrix, we decided to propose a completely new computation device based on creation and annihilation, which are among the most elementary operations which can be conceived in physics: adding or removing a quantum of energy to/from a quantum system. Studying these P systems will certainly yield interesting observations both from the computational point of view and from the quantum physics side. The first results we have obtained are that – differently from the classical version – these systems do not need to use priorities to be universal; moreover, the use of creation and annihilation allows the definition of linear (but non-unitary) operators, that allow one to efficiently solve NP-complete problems. The latter aspect should be further investigated, since this result is in contrast with what can be done with "traditional" quantum computers.

Please contact:
Alberto Leporati
Dipartimento di Informatica, Sistemistica e Comunicazione
Università degli Studi di Milano – Bicocca
E-mail: alberto.leporati@unimib.it

The Spanish Network on Biomolecular and Biocellular Computing: Bio-inspired Natural Computing in Spain

by Mario de Jesús Pérez Jiménez, Alfonso Ortega de la Puente and José M. Sempere

The Spanish Network on Biomolecular and Biocellular Computing (Redbiocom) is a consortium of seven Spanish research groups whose research activities focus on the bio-inspired approach to Natural Computing. The Network was founded in 2009 and it was funded by the Spanish Ministry of Science and Innovation under the Complementary Action TIN2008-04487-E/TIN.

Redbiocom is composed of the Bio-inspired Computing and Complex Systems group at Autonoma University of Madrid (UAM), the Computational Biology and Bioinformatics Group at Balearic Islands University (UIB), the Decision Modelling, Computation and Simulation group at University of Lleida (Ull), the Natural Computing group at Polytechnic University of Madrid (UPM-I), Laboratorio de Inteligencia Artificial (LIA) at Universidad Politécnica de Madrid (UPM-II), the Computation Models and Formal Languages group at Polytechnic University of Valencia (UPV), and the Natural Computing group at University of Seville (USe).

The main research areas of Redbiocom are Membrane Computing and P Systems, Networks of Bio-inspired Processors, DNA computing and Synthetic Biology, Computational Biology and Bioinformatics.

Current research projects of the consortium in these areas are:

- the "Alignment of metabolic networks modelled as Petri nets and P-systems" (UIB), where researchers try to generalize the comparison algorithms developed for Petri nets to P-systems, exploiting the relationship between both models
- the construction of a simple computer, using bacteria rather than silicon (UPM-II) in the European Project BACTOCOM
- the simulation of biological processes and design of biomolecular information processing devices (UPM-II)
- the development of a complete platform for natural computation software, its application to concrete linguistic problems, and the proposal of techniques in the field of evolutionary computation which will hybrid different disciplines (evolutionary computation, formal languages, data structures in the theory of algebraic complexity, automatic learning) and makes it possible to provide automatic (genetic) programming tools for natural computation (UAM)
- The full development of a computational model based on bio-inspired operations over strings organized as a network of bio-inspired processors (UAM, UPM-I and UPV)
- The development of a multi-compartmental, stochastic and discrete modelling framework based on P systems for the study of systems biology models ranging from bacterial colonies to ecosystems (USe). From a synthetic biology perspective this project aims at developing models of synthetic gene regulatory networks inducing desirable phenotypes in multicellular bacterial systems. These models are used as blue-prints to assess the viability of the different possible designs prior to their implementation in the wet lab
- A systems and synthetic biology approach to the modelling and implementation of biological systems with prefixed behaviour (USe and Prof. Gheorghe Paun, initiator of the Membrane Computing discipline). Researchers associated with this project participate as instructors in the team that represents the University of Seville in the International Genetically Engineered Machines competition (iGEM), the premiere undergraduate Synthetic Biology competition
- The production of a simulation tool, based on the Membrane Computing paradigm, that helps the experts to study different ecological systems (Ull).

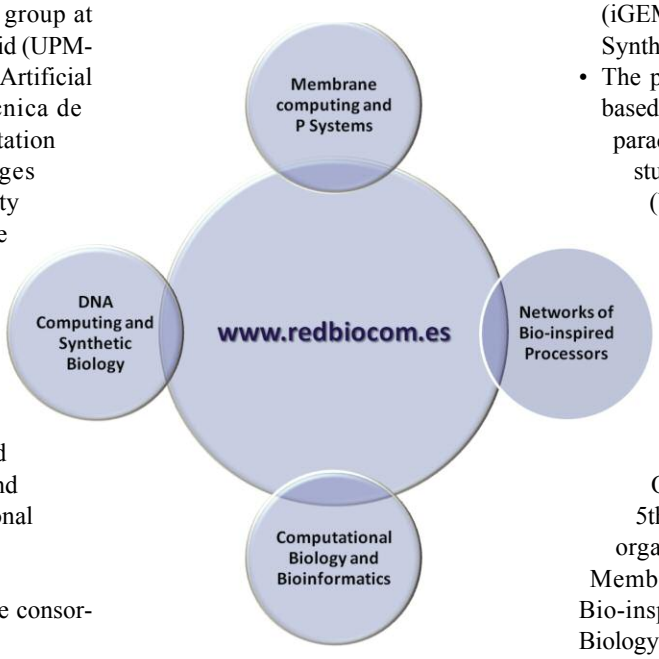


Figure 1: main research areas of Redbiocom.

Currently, the joint efforts of the research groups in the network have been oriented to organize the First International School on Biomolecular and Biocellular Computing (ISBBC) which will be held in Osuna (Spain) from September 5th to 7th, 2011. The school will be organized in three different topics: Membrane Computing, Networks of Bio-inspired Processors and Synthetic Biology and DNA computing.

Links:

http://www.redbiocom.es
http://www.p-lingua.org/wiki/index.php/Main_Page
First International School on Biomolecular and Biocellular Computing
http://www.redbiocom.es/ISBBC/ISBBC11

Please contact:
Mario de Jesús Pérez Jiménez
University of Seville, Spain
E-mail: marper@us.es

Alfonso Ortega de la Puente
Autonoma University of Madrid
E-mail: alfonso.ortega@uam.es

José M. Sempere
Polytechnic University of Valencia / SpaRCIM, Spain
E-mail: jsempere@dsic.upv.es

Expanding Formal Language and Automata Theory: Bio-inspired Computational Models

by Erzsébet Csuhaj-Varjú and György Vaszil

One of the goals of research in bio-inspired computing is to create new and powerful computational paradigms based on the study of the structure and behaviour of living systems. The investigations can be based on different mathematical disciplines. The Theoretical Computer Science Research Group of SZTAKI aims to expand the classic fields of automata and formal languages to explore the limits of syntactical approaches in describing natural systems.

One major characteristics of living systems is the distributed organization of their components. For this reason, our investigations concentrate on distributed bio-inspired computational models. We enhance the tools and techniques provided by formal language and automata theory with novel elements to obtain computational models which could help to provide a better understanding and a more precise description of the theoretical principles, the driving forces behind natural processes.

We are interested in both classical and unconventional characteristics of the obtained computational paradigms: their computational, descriptional, and communication complexity, their robustness, the patterns and dynamics of their behaviour, and the dependence of these properties on the structure, organization and functioning of the system.

In recent years, a significant amount of research has been devoted to membrane systems or P systems, constructs abstracted from the architecture and development of the living cell, first introduced by Gheorghe Paun in 1998. The basic variant of these systems consists of structures of hierarchically embedded membranes that delimit regions which contain objects. The objects correspond to molecules or chemical elements which evolve according to evolution rules, or move from region to region according to communication rules.

Re-considering the concept of automata, we have defined P automata, purely communicating accepting P systems which combine characteristics of both classical automata and distributed natural systems. P automata resemble classical automata in the sense that in each computational step they receive input from their environment, and this input influences their operation. What makes them different from classical automata is that the workspace that they can use for computation is provided by the objects of the already consumed input. The objects which enter the system become, in a sense, part of the description of the machine, that is, the input, the object of computation and the device which executes the computation cannot be separated. This is a feature that can usually also be observed if we interpret natural processes as "computations". Thus, in this sense P automata can be considered as a type of "natural automata".

We have characterized several classical language classes in terms of P automata. In cooperation with Oscar H. Ibarra, we determined variants which are alternatives of a Turing machine. One of these gives a "natural" representation of the class of context-sensitive languages, well-known in classical formal language theory. In a joint work with Jürgen Dassow, we have also provided a natural extension of the notion of regular languages and that of finite automata for the case of infinite alphabets.

In the future, we plan to perform investigations in the theory of P automata in several directions, to make the resemblances and the differences between classical automata and P automata more explicit.

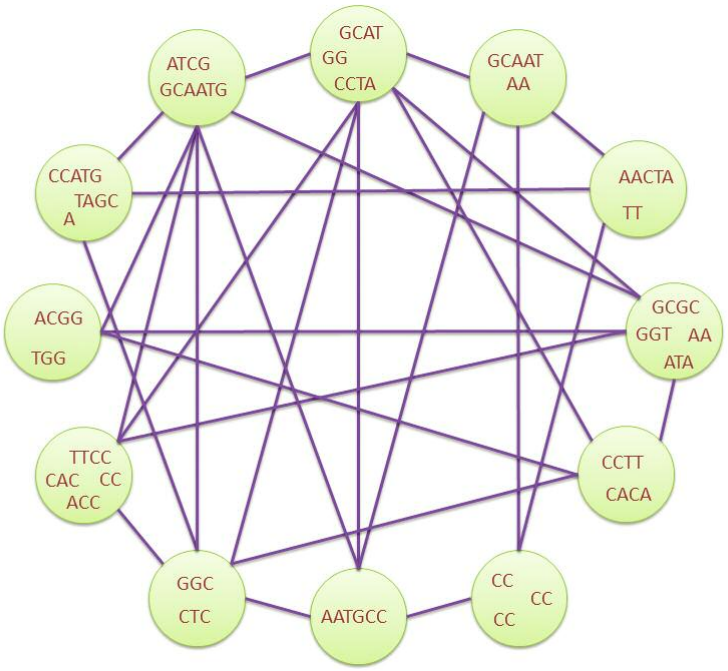


Figure 1: A Network of Bio-inspired Language Processors. The nodes process multisets of strings and communicate with each other.

Another important focus of our research is the study of networks of bio-inspired language processors. These constructs consist of bio-inspired rewriting systems (language processors) which operate on sets or multisets of words and are located at nodes of a virtual graph. The processors use their operations to rewrite the collection of words at the nodes and then redistribute the

resulting strings according to the communication protocol assigned to the system.

Due to their possible practical relevance, constructs based on operations inspired by the behaviour or properties of DNA strands are particularly important. One of the first models was the test tube sytems based on splicing (our joint work with Lila Kari and Gheorghe Paun). Through this research we have shown that several other variants of these constructs offer alternatives to Turing machines even with minimal size: networks with components based on an operation that mimics the Watson-Crick complementarity phenomenon of DNA strands (in cooperation with Arto Salomaa), or with components based on splicing and filters inspired by the laboratory technique called gel electrophoresis (in cooperation with Sergey Verlan).

Recently, we have been studying networks of evolutionary processors, where the operations are formal language theoretic counterparts of point mutations, evolution of the genome, i.e. insertion, deletion, and substitution. Our main future goals in the area include the exploration of the "limits" of these simple, basic operations, the identification of the cornerstones and borderlines between decidability and undecidability. In cooperation with Artiom Alhazov, Carlos Martín-Vide, Victor Mitrana and Yurii Rogozhin, we have demonstrated that these distributed systems of very simple computing devices may possess the computational power of Turing machines, even with networks and components of very small size.

Via properties of changing string collections, in the framework of networks of bio-inspired language processors, population dynamics, behavioural patterns and motifs can also be studied, thus new directions for language-theoretic approaches can be opened. In the case of networks with deterministic Lindenmayer systems as components (models of developing systems), initial results have been obtained (in cooperation with Arto Salomaa). We plan to explore these topics in the future.

The group is in close cooperation with members of the European Molecular Computing Consortium; the investigations are supported by the Hungarian Scientific Research Fund, OTKA, Grant no. K75952.

Links:
P automata:
http://www.scholarpedia.org/article/P_automata

P systems webpage:
http://ppage.psystems.eu

Theoretical Computer Science Research Group: www.sztaki.hu/tcs

Please contact:
Erzsébet Csuhaj-Varjú
SZTAKI, Hungary
Tel: +36 1 279 6139
E-mail: csuhaj@sztaki.hu

György Vaszil
SZTAKI, Hungary
Tel: +36 1 279 6121
E-mail: vaszil@sztaki.hu

Capturing Biological Frequency Control of Circadian Clocks by Reaction System Modularization

by Thomas Hinze, Christian Bodenstein, Ines Heiland, Stefan Schuster

Exploration of chronobiological systems is emerging as a growing research field within bioinformatics, focusing on various applications in medicine and agriculture. From a systems biology perspective, the question arises as to whether biological control systems for regulation of oscillatory signals utilize similar mechanisms to their technical counterparts. If so, modelling approaches adopted from building blocks can help to identify general components for frequency control in circadian clocks and can provide insight into mechanisms of clock synchronization to external stimuli like the daily rhythm of sunlight and darkness. Within the Research Initiative in Systems Biology funded by the German Ministry of Education and Research, we develop new methods to cover temporal aspects of biological information processing employing oscillatory signals.

Oscillatory signals play a major role in triggering time-dependent processes like melatonin and serotonin segregation to initiate tiredness and alertness. Biochemical core oscillators are simple devices that generate continuously running clock signals by periodically alternating substrate concentrations. Therefore, astonishingly small reaction networks comprising at least one feedback loop suffice to keep the system running. It is likely that numerous evolutionary origins led to oscillatory reaction networks in biological systems, while a number of independent attempts led to the technical construction of single clocks or clock generators. The situation becomes more complicated if several core oscillators start to interact in concert with environmental rhythmicities. Resulting biological systems are commonly driven to achieve a synchronous behaviour, resulting in an evolutionary advantage for exploitation of environmental resources. Correspondingly, technical clock synchronization is frequently motivated by the need to follow a global time.

The way in which clock synchronization occurs differs between computer systems and biological systems. While in distributed computer systems, algorithmic approaches predominate, biological systems adjust their clocks more gradually. This gradual adjustment

might include sequences of dedicated modifications in molecular structures or compartmental dynamics. Typically, its description is either based on reaction-diffusion kinetics or employs more abstract analytic techniques adopted from general systems theory. What these state-of-the-art approaches in systems biology have in common is that they both exploit systems of differential equations derived from kinetic laws of the underlying set of reactions and transportation processes. Coping with the complexity of those monolithic models is a challenging and error-prone task. Additionally, the modelling often coincides with some incomplete or imprecise information about the desired network topology and its kinetics. To overcome these insufficiencies, we suggest a specific concept of reaction system modularization inspired by engineering..

Our concept is based on the assumption that 'structure follows function'. Although, there are many strategies to achieve a certain network function, the pool of sufficient network candidates can be divided into compositions of a low number of elementary functional units called modules. This term is not new in systems biology when considering recurrent motifs conserved in metabolic, cell signalling, and gene regulatory networks. We extend its notion in terms of information processing: In this context, a module is able to fulfill an elementary computational task. Here, the spatio-temporal course of substrate concentrations along with molecular and compartmental structures acts as data carrier. Beyond logic and arithmetic functions carried out by the module's steady-state behaviour, simple buffer and delay elements contribute to a collection of biochemical modules, each of which comprises a few molecular species and reactions. When combining modules to form reaction networks capable of a more complex functionality, we permit shared molecular species among distinct modules. This way of coupling enables compact network topologies in accordance with observations from in-vivo studies. Moreover, there is no need for further interface specifications. In most cases, the module behaviour can be captured by chemical counterparts of transfer functions significantly reducing the number of distinct parameters by keeping the relevant characteristics of the entire network.

A case study of our modularization concept addresses biological frequency control of circadian clocks, biochemical regulatory circuits resembling phase-locked loops. Corresponding circuits comprise three modules:

- a core oscillator whose frequency has been controlled to adapt to an external stimulus. Intensity and periodicity of environmental light converted into specific proteins by a photo cascade represents a typical stimulus
- a signal comparator responsible for determining the deviation between signals produced by the core oscillator and by the external stimulus. It carries out an arithmetic task. Interestingly, a single complex formation conducting a mathematical multiplication succeeds here whereas more sophisticated mechanisms could be involved instead

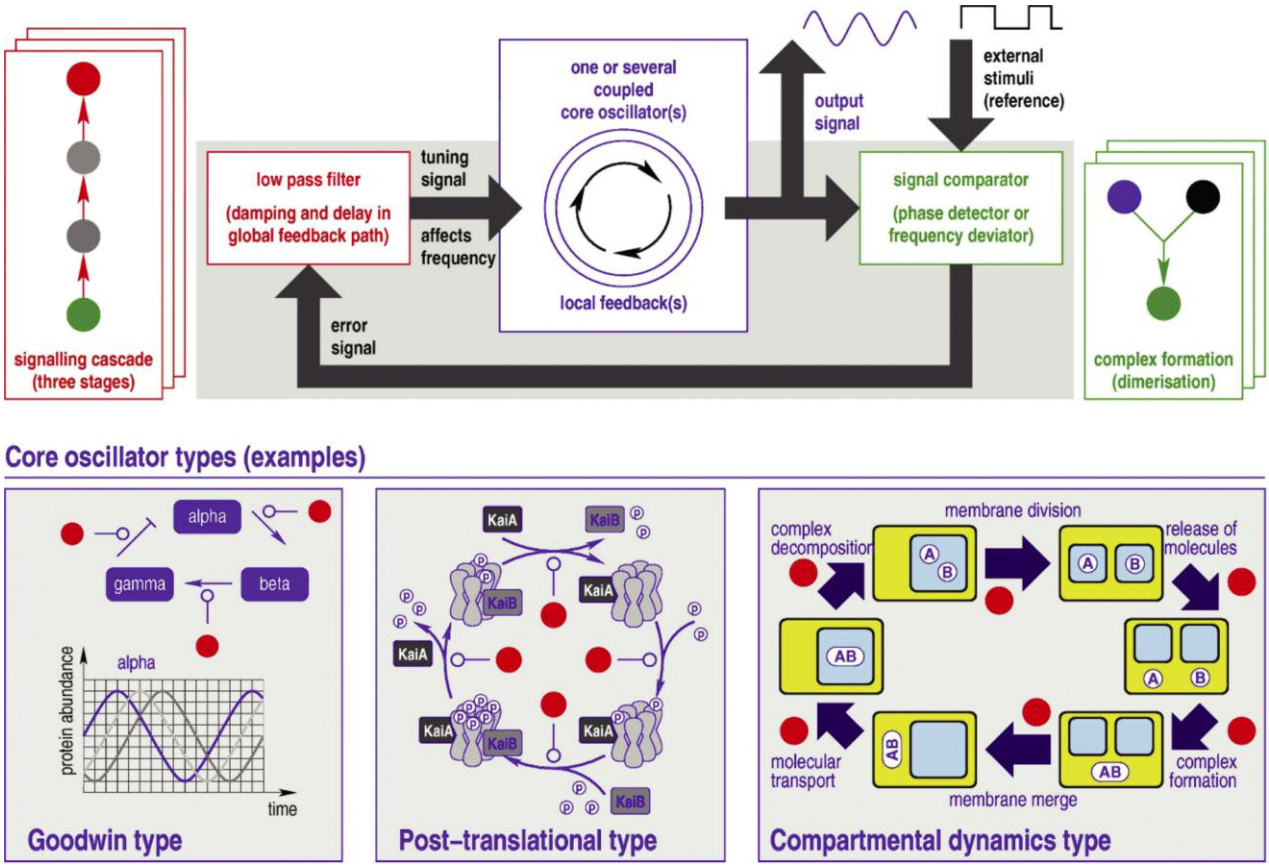


Figure 1: General scheme of a pure chemical frequency control system based on the concept of phase-locked loops (PLL). The upper part shows the coupling structure of the three essential modules: core oscillator, signal comparator, and low pass filter. Each module can be represented by numerous reaction networks. For instance, complex formation suffices for acting as signal comparator while a signalling cascade exemplifies a low pass filter. Different types of core oscillators complete the control circuit.

- a biochemical low pass filter providing a global feedback loop. It converts the signal comparator output into a delayed and damped tuning signal which is used by the core oscillator to adjust its frequency. A signalling cascade gives an example. Its behaviour can be specified by a Bode diagram which depicts the intensity of signal weakening subject to different frequencies. The core oscillator must be able to vary its frequency according to the tuning signal produced by the low pass filter. There are numerous types of core oscillators found in circadian clocks. The majority reveals the Goodwin type, a cyclic gene regulatory network composed of mutual activating and inhibiting gene expressions. The most effective way to influence its frequency is modification of protein degradation rates. Furthermore, core oscillators can be of post-translational type, exploiting a cyclic scheme of protein phosphorylation, complex formation, or decomposition. Here, the involved catalysts affect the frequency. The third type of core oscillators includes compartmental dynamics advantageously modelled using membrane systems combining a representation of dynamical structures with tracing their spatio-temporal behaviour.

Link:
http://pinguin.biologie.uni-jena.de/bioinformatik/Forschung/index.html#Project_2

Please contact:
Thomas Hinze
Friedrich Schiller University Jena, Germany
Tel.: +49 3641 9 46463
E-mail: thomas.hinze@uni-jena.de

Engineering with Biological Systems

by Fernando Arroyo, Sandra Gómez and Pedro Marijuán

Within the Natural Computing Group GCN we address two working perspectives: on the one hand, we propose new bioinspired computational models and architectures, and on the other, we propose computational techniques and user friendly tools to support the advancements in synthetic and systems biology. An in-depth reflection on the distinctive nature of biological information is necessary in both directions; our group has actually established several research lines and projects in the "informational" confluence of the two working perspectives.

From the point of view of the bioinspired computational models we intend to develop mathematical and computational models abstracted from the information processing that is present in all living cellular systems. The emphasis is at the cellular level; and the modelling methods capture the internal structure of the cell and the cellular interactions in an appropriate way such that they allow for the description of what are essentially massively parallel computational systems. We study the problem solving capabilities inherent in the living cell, which are realized by maintaining a special, "meaningful" relationship with the internal/external environment, integrating the self-reproduction processes within the information flow of incoming and outgoing signals. The designs encoded by natural systems are optimized by evolution to provide solutions to physical problems posed by both individual development and continued viability across many environments and evolution.

From a computational point of view, the living cell may be viewed as a DNA-based molecular computer, endowed with an enzyme-protein operating system, which is coded into the DNA memory bank. We are attracted by the new possibilities for computing offered by these self-organizing, interlinked, and evolvable molecular systems: practically an unbound memory and a huge parallelism which might be used for solving intractable problems in a reasonable time. Furthermore, these molecules participate in very complex networks in cellular subsystems, including regulatory networks for gene expression, intracellular metabolic networks, and both intra- and intercellular communication networks. Subsequently the new biocomputing ideas extracted from these core subsystems have potential to be applied not only to biological-cellular instances, but also to modelling of interactive, self-organizing processes in many other fields: population interactions, ecological trophic networks, industrial ecosystems and companies, virtual economies, social and cultural dynamics, etc. We are sure the results derived from the advancement of the bioinformational research program will open new avenues for information science and technology, and will be conducive to a paradigm shift in the way bioinspired technologies are conceived and applied.

From the point of view of the computational techniques and tools to support synthetic and systems biology, we pretend the realization of simulations and tools that are user-friendly and can support the study, analysis, and extraction of further information in an intelligent and meaningful way. Both molecular dynamics and cellular systemic interactions will be considereded. In regard to molecular dynamics, we specifically attempt an analysis of the prion propagation and the protein aggregation phenomena (based on altered processes of molecular recognition) with the aim of helping researchers in their studies about the detection and treatment of neurodegenerative disorders. With regard to cell systems interaction we attempt a consistent approach to the multiple varieties of information in the living cell, also by starting out from the conceptualization of molecular recognition phenomena. Subsequently, an elementary approach to the "informational architectures" behind cellular complexity may be chartered. In the interplay of the different informational architectures, two crucial cellular subsystems should be highlighted: on the one side the transcriptional regulatory network, and on the other, the cellular signalling system that is in charge of the interrelationship with the environment and how the topological governing of

this network is deployed by the cellular signalling system in charge of the interrelationship with the environment. Models and simulations of this basic interaction will be applied to Mycobacterium tuberculosis signalling in living tissues (in cooperation with an ongoing research medical project). More generally, as suggested above, the embodiment of functional protein agents and the peculiar handling of DNA sequences along the evolutionary process will suggest a parallel with the von Neumann scheme of modern computers, including the cellular capability to "rewrite the DNA rules" along ontogenetic development. In these theoretical and applied research areas we collaborate with Biomolecular Research Groups in the Complutense University and Biological Research Center of Madrid, and with the Bioinformation Group of the Aragon Institute of Health Sciences of Spain, respectively.

Links:
http://www.gcn.upm.es
http://sites.google.com/site/pedrocmarijuan/

Please contact:
Fernando Arroyo Montoro
Universidad Politécnica de Madrid, Spain
E-mail: fernando.arroyo@upm.es, pcmarijuan.iacs@aragon.es

Artificial Wet Neuronal Networks from Compartmentalised Excitable Chemical Media

by Gerd Gruenert, Peter Dittrich and Klaus-Peter Zauner

Following the analogy of biological neurons, the NEUNEU (Artificial Wet Neuronal Networks from Compartmentalized Excitable Chemical Media) project aims at using droplets of a chemical reaction medium to process information. In this EU project, the excitable chemical Belousov-Zhabotinsky medium is packaged into small lipid-coated droplets which form the elementary components of a liquid information processing medium. Droplets communicate through chemical signals and excitation propagates from droplet to droplet. Among the future applications of molecular information processors is their potential for fine grained control of chemical reaction processes.

Our modern society and technology is very much dependent on smart automatic control devices, from cell-phones and electronic driver assistance systems in cars to computer controlled manufacturing processes. In the area of chemical production processes, however, the level of control achieved so far is crude compared with what is seen in nature. Living cells craft molecules one-by-one with quality control directly at the assembly stage of each molecule. In contrast, chemical technology controls reaction conditions only at the level of bulk materials and subsequently the desired product needs to be extracted from the mixture of substances formed in the reaction process. As a consequence, the complexity of molecules and the concomitant functionality of materials that can be manufactured today falls far short of those seen in nature.

Attempts to achieve an increasingly finer control of chemical production processes currently face the challenge of bridging from electronic control technology to the surfaces that mediate chemical reactions. In a different approach, the NEUNEU project aims to include computational capabilities directly into different media, migrating the control from a conventional computer outside the system of interest directly into the system itself, eliminating the need for a complicated interface.

Another interesting application of molecular information technology is the potential for smart drugs, capable of

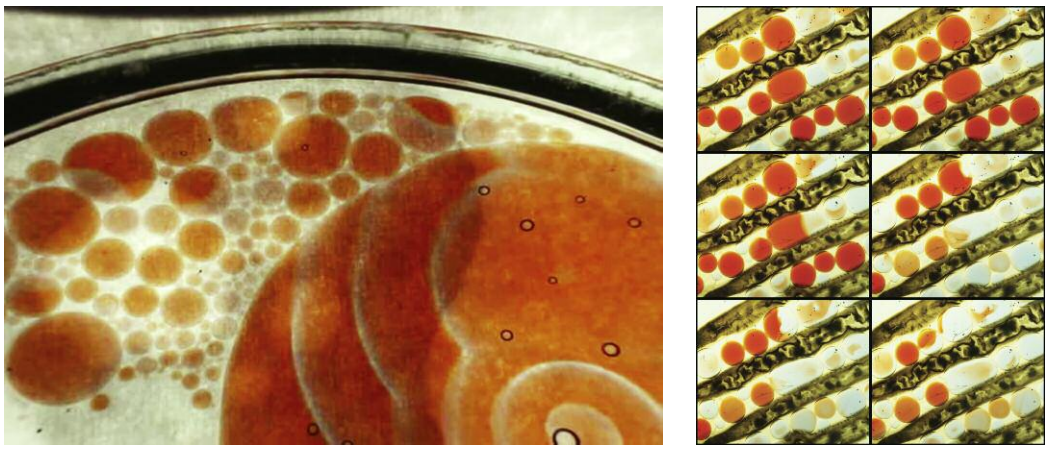


Figure 1: From left: A) Belousov–Zhabotinsky activation waves propagating in 1 to 10 millimeter sized lipid-coated droplets in oil (Credit: Gorecki Lab, Warsaw). (B) Manually aligned droplets of BZ-reaction medium (Credit: Josephine Corsi, Univ. of Southampton).

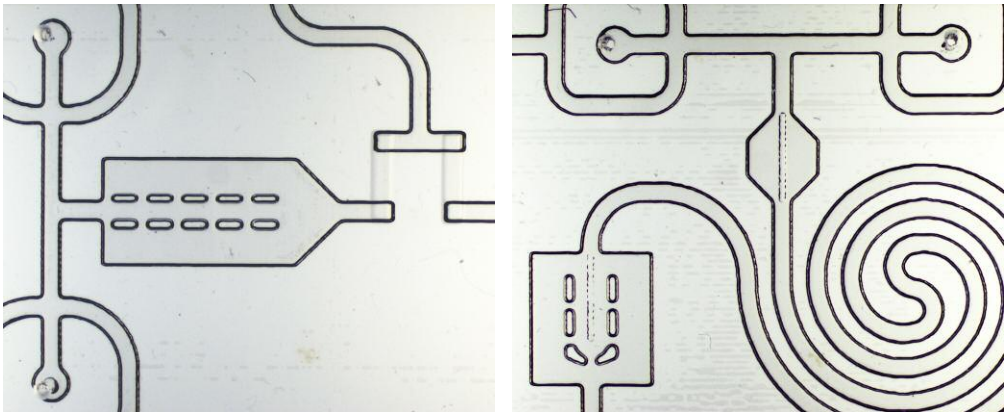


Figure 2a, 2b: Examples of microfluidic structures for generation and handling of droplets.

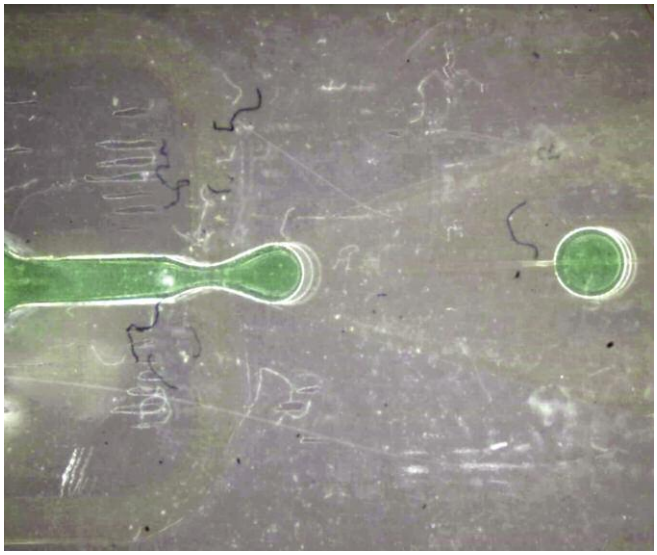


Figure 2c: Generation of a droplet within a microfluidic structure (not visible).

performing elementary logical decisions to determine whether the right position in space and time is reached to release certain drugs. This would not only make the use of drugs more convenient for the patient but also lead to more effective and reliable medications.

Before information technology can be tightly interwoven with chemical and biochemical systems, however, it will be necessary to find out where the concepts of conventional information processing can be mapped into the chemical realm and where new paradigms need to be developed. The NEUNEU project decided to explore this path with a minimal system that exhibits the properties (signal transmission, signal gain, self-repair) desirable for a molecular information processing architecture that harbors the potential to scale to applications.

To explore the concept of performing computations with excitable media we use the Belousov-Zhabotinsky (BZ) medium. The BZ reaction was discovered in the 1950s to be an oscillating reaction, existing far from the thermodynamic equilibrium. Though there are variations, the BZ-mixture can be prepared from potassium bromide, malonic acid, sodium bromate, sulfuric acid and ferroin as redox indicator.

When the system is oscillating, the indicator is continuously switching between its oxidized and reduced form, changing its color between blue and red or between red and white, as seen in Figure 1. Stirring the system leads the whole mixture to exhibit similar behaviour in all parts of the test tube. On the contrary, leaving the mixture relatively undisturbed in a flat petri dish, the BZ medium generates beautiful two-dimensional wave patterns.

Because we want to control the signals that are transmitted through the chemical medium, continuous excitations are not desirable in this project. Here, the BZ medium is mixed in proportions that do not allow a spontaneous start of an oscillation. Instead, the excitation needs to be triggered from the outside (eg, by a silver wire) or by an already existing excitation wave. Hence we call the state of the medium "excitable" or "sub-excitatory". When the medium is excitable, a wave propagates equally in every direction. So the state of a droplet can be simplified by assuming a well-stirred reactor for each droplet.

Using the "sub-excitatory" condition alternatively, we can also include logic elements inside single large drops. In this case, waves do not spread in every direction, but preserve their shape and direction as illustrated in Figure 3A.

When we drop water containing BZ medium into oil, the phases do not merge and droplets form automatically. We are going to use microfluidics to produce droplets of smaller volumes, with higher precision, and in large quantities (Figure 2). Wrapping up the BZ reaction into these small droplets has the advantage of discretizing the otherwise continuously propagating excitations into precise units.

Lipid molecules contained in the oil phase self-assemble at the surface of the droplets and stabilize the droplets against merging. Living cells are also

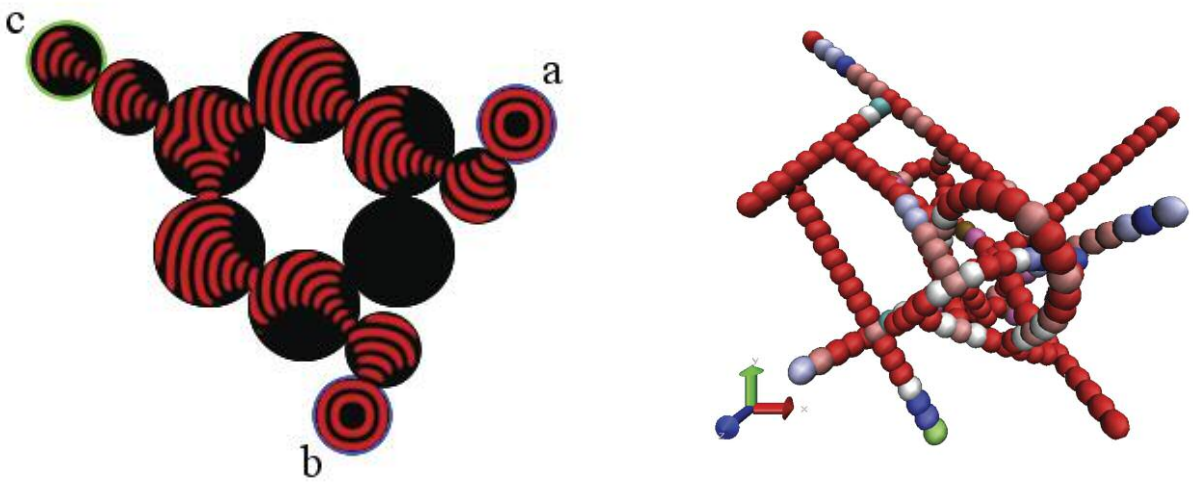


Figure 3a (left) Simulation of directed waves in sub-excitable medium within a network of droplets with two different inputs a, b and output c (image by Julian Holley, University of the West of England, for animation see link below). 3b: Stochastic 3-D simulation of a droplet network counting the number of activated inputs (image by Gerd Gruenert, FSU Jena).

covered with lipids, but in this case lipids assemble between two aqueous compartments and therefore form the double layer typical for biomembranes. The amphiphilic lipid molecules assembling at the border between the oil and and the "water with BZ" phase, produce a lipid monolayer in our system.

When two of the droplets come into contact, the lipid monolayers coating each droplet can form a double layer similar to a biological membrane. As a consequence it is possible to insert membrane channel proteins at the interface between two droplets to facilitate the exchange of chemical compounds and consequently the propagation of the BZ medium excitation from droplet to droplet.

By varying the coupling between droplets, the droplet radii, and BZ medium compositions, we will generate droplets with a wide variety of properties, such as excitability, oscillation phase length or refractory times. Controlling these properties should allow us to engineer droplet networks with computational capabilities as for example shown in Figure 3B.

The NEUNEU project is funded by the EU Seventh Framework Programme for three years (FP7, ICT, FET, see link below) since February 2010. It brings together biochemical experimentalists as well as theoretical computer scientists. In the team of Maurits de Planque and Klaus-Peter Zauner (University of Southampton) and Jerzy Gorecki's lab (Institute of Physical Chemistry, Polish Academy of Sciences, Warsaw) the physics and chemistry of small lipid droplets and of the Belousov-Zhabotinsky reaction are investigated, both theoretically and practically. The theoretical foundations, implications and possibilities of droplet based computing devices are elaborated in the research groups of Andy Adamatzky (University of the West of England, Bristol) and Peter Dittrich (Bio Systems Analysis Group, Friedrich-Schiller-University Jena).

For further recent activities in European BioChem IT research see the COBRA initiative (link below).

Links:
http://www.neu-n.eu/
http://uncomp.uwe.ac.uk/holley/sim/sim.html
http://www.cobra-project.eu
http://cordis.europa.eu/fp7/ict/programme/fet_en.html

Please contact:
Peter Dittrich
Friedrich Schiller University Jena
Tel.: +49 3641 946460
E-mail: Peter.Dittrich@uni-jena.de

New Robustness Paradigms: from Nature to Computing

by Giancarlo Mauri and Ion Petre

In the intracellular and the intercellular environment we observe architectural designs and dynamical interactions that are very different to those in human-designed systems: particles that are partly transported and partly move chaotically; fierce competition for resources; a vital need to respond fast, yet efficiently, to external stimuli; etc. Many details about the system-level motifs responsible for robustness, performance, and efficiency in living cells have been discovered in the last decade within computational systems biology. We are currently working on applying the lessons learned from the robust organization, functioning, and communication strategies of living cells to computing, and on integrating them into the design of a novel computing paradigm.

Computing resources in modern society, especially in Europe, are widely available and range from fixed resources (such as desktop computers, servers, game consoles, infrastructure systems), to mobile resources (such as portable computers, smartphones, car navigation systems), to virtual resources (also called cloud-based resources). Computer science is taking notice of these new technological developments and has started adapting its central computing paradigms from centralized, pre-programmed solutions to decentralized, emerging solutions, able to take advantage of the variety of resources that may be available during computations.

The goal of this new approach is to make possible environments where computing resources of many types are smoothly integrated into on-going computations, even if each resource is only sporadically available. An example of such an environment is that of a future smart transportation system, where each car has its own goals (such as reaching its destination given a number of constraints: some compulsory intermediate route points, a maximum duration of the trip, a maximum energy consumption, and others), and it interacts with its environment to reach its goal. The interaction may involve local communication with other cars to gather and distribute information about the traffic situation (such as traffic jams, accidents, alternative routes) and with the transportation infrastructure itself on aspects such as road repairs, speed limits and weather predictions. Collective decentralized decisions may be taken ad-hoc in this environment, such as collective actions to avoid imminent collisions or increased traffic jams, involving changes of the constraints, which in turn will affect the goals of each car and the decision they make further. The system has no central server to overlook the computation, but rather it is self-organizing and attempts to self-optimize on the basis of brief ad-hoc interactions between the actors and on decentralized decision making.

The robustness in decentralized systems, with self-organizing, emerging architecture, cannot be achieved through top-down structural designs that include, as in "classical computing", well specified control and through pre-programmed responses to various (fixed) failure scenarios, typically based on fixed network architecture. Instead, the focus is on dynamic activation of computing resources, dynamic decision making, and self-adaptation, all emerging from processors of weak (non-universal) computing power and of sporadic availability. Biology serves here as an ideal source of inspiration. Biological robustness is typically implemented through mechanisms such as multiple feedback loops, alternative pathways and function redundancy, taking advantage of an environment where many different types of particle are constantly present. Cellular robustness manifests through self-repair mechanisms, the ability to mount efficient responses to changes in the environment, tolerance for broad parameter spaces, multiple response pathways, etc. We work on taking these lessons from computational systems biology, and applying them to the design of novel paradigms of computing based on large numbers of processors, each having limited power and with sporadic availability. Indeed, emerging computing platforms, such as Internet-based computing, or cloud computing offer a perspective where high computing power can be made available on demand. We aim to expand beyond the typical distributed computing paradigm where the network architecture and the communication mechanisms are fixed, and each processor is capable of universal computations, towards a paradigm where processors of limited power are able to engage in ad-hoc communications and cooperation with any available partner, and where the computing power engaged in a specific task can be increased or decreased dynamically depending on the evolution of the computation. The inspiration again comes from biology, where enzymes, catalysts, transcription factors, etc can be made available on-demand in large quantities, and then released for other tasks once they are not anymore needed.

This research is carried out in collaboration with Diego Liberati (CNR, Italy), Alessandro Villa (University of Lausanne, Switzerland), Tatiana Guy (Institute of Information Theory and Automation, Academy of Sciences of the Czech Republic), and Jüri Vain (Tallinn University of Technology). Other parts of the project focus on bio-inspired cooperation and interaction for decentralized decision making, brain-inspired evolvable networks for decision making, and on applications to robot swarm systems. The multi-disciplinary character of the project makes the enterprise possible through the combined, multi-disciplinary expertise of the consortium members, spanning from computer science to biomedicine, information systems, and neuroscience.

Please contact:
Giancarlo Mauri
Universita di Milano-Bicocca, Italy
E-mail: mauri@disco.unimib.it
http://www.bio.disco.unimib.it/~mauri/

Ion Petre
Åbo Akademi University, Turku, Finland
E-mail: ipetre@abo.fi
http://www.users.abo.fi/ipetre/

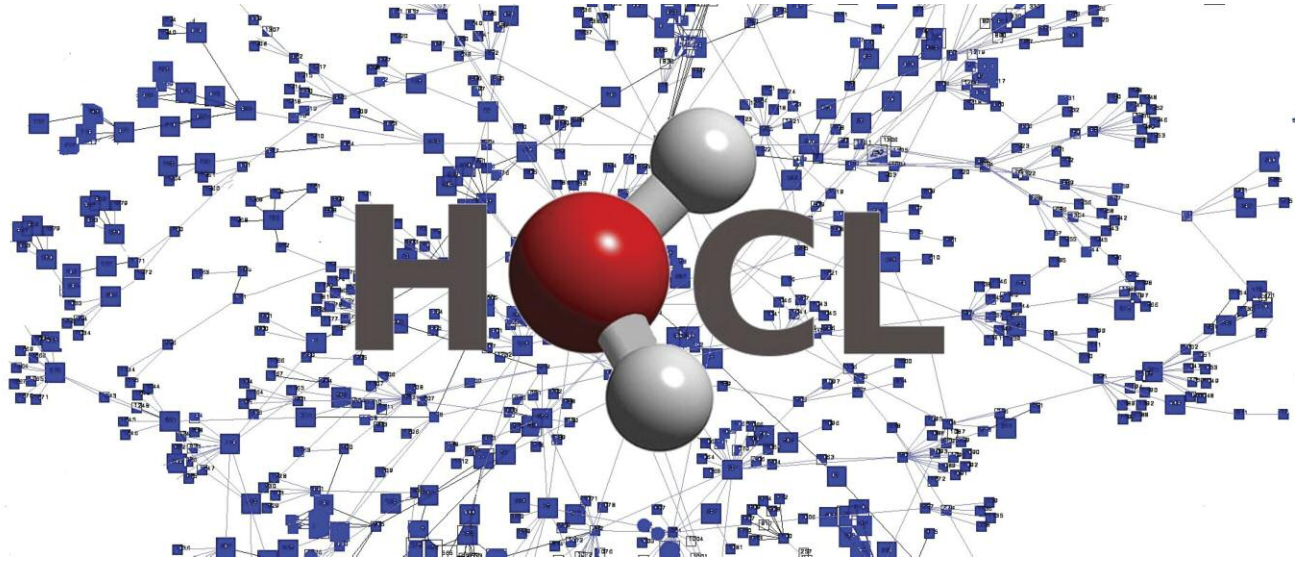
Towards a Chemistry-Inspired Middleware to Program the Internet of Services

by Jean-Louis Pazat, Thierry Priol and Cédric Tedeschi

The Internet of Services has emerged as a global computing platform, where a myriad of services and users are interacting autonomously. Being able to compose, coordinate and adapt such services on a large scale constitutes a new challenge in the distributed computing area. Nature-inspired models have recently regained momentum in this context, exhibiting properties that might assist with programming such a platform. Two years ago, at the IRISA/INRIA Rennes Bretagne Atlantique Research Centre, in Brittany, France, the Myriads team started a research activity with the aim of starting the development of the next generation middleware system able to fully leverage such computational capabilities, based on a chemical model.

The World Wide Web, as we have used it in the last two decades, i.e., as a communication platform, seems to have come to an end. Applications invaded the virtual communication world. We are no longer just surfing; we are accessing a service through an application. This shift of paradigm is experienced, for instance, when you connect your smart phone to your favourite application store. Internet as a computing platform has become an ecosystem comprising a myriad of heterogeneous and autonomous services encapsulating IT components such as storage space, computing power, software or sensors. To be able to leverage such computing power, one needs to compose, coordinate and adapt such services dynamically, according to users' requests. This virtual ecosystem shares some similarities with chemistry concepts: users, services and pieces of information can be seen as molecules interacting freely in the great WWW chemical solution, sometimes meeting to react and produce new information.

The chemical model naturally expresses dynamics, parallelism and decentralization. Within this model, a program is seen as a solution of interacting molecules, reacting together according to some chemical laws (or rules). These reactions take place in an implicitly parallel, non-deterministic, autonomous and distributed manner. As a simple example, let us consider the problem of finding the maximum value among a set of integers. Imagine a set of molecules representing these integers in a solution. Now, introduce a rule specifying how two integers that meet should react: they are consumed in one reaction that produces a new molecule with the highest value of the two initial integers. Step by step, in parallel, reactions will make the solution converge to its inertia: only one molecule with the highest value remains in the solution. The HOCL language (Higher-Order Chemical Language), which the team developed in 2007, provides a unified vision of chemical programs and data: every virtual entity is a molecule floating in the solution and interacting with others. In particular, rules can modify other rules, programs modifying programs. This higher-order property gives a mean to express dynamic coordination and adaptation. An HOCL interpreter has been developed that will be the core component of



The Higher-Order Chemical Language developed by the "Myriads" team provides a unified vision of chemical programs and data.

our on-going work: the development of a middleware prototype exploiting HOCL properties.

Our project consists of two main research tracks. In the first, following a top-down approach, we leverage HOCL properties to express the decentralized and dynamic coordination and adaptation of services. A composition of services is usually expressed through a workflow, i.e., the specification of data and control dependencies between services to achieve a given global task. Based on the chemical representation of the workflow, services, equipped with an HOCL engine, coordinate themselves autonomously at runtime, without any central coordinator or human intervention. We have recently shown that any complex workflow pattern can be expressed and executed in a decentralized fashion, by defining the relevant HOCL rules, composing them and distributing them among the engines of participating services. Services are similarly capable of self-adaptation to actual conditions of the platforms. These areas of research are currently being concretized by the development of the upper layer of our chemical middleware. In this series of works, the team collaborates in Europe with CNR in Naples, Italy and SZTAKI in Budapest, Hungary. Two of the team's PhD students, Héctor Fernandez and Chen Wang, are focusing on these aspects.

The second research track is bottom-up and aims at making the whole a reality, by constructing the low-layer of this software. Here, the main challenge is to be able to implement a distributed chemical machine, capable of making the needed reactions happen even when molecules are distributed over the whole Web, i.e., on an infinitely large and unreliable platform. This raises many new theoretical and practical challenges, such as searching efficiently for several reactives atomically, synchronizing the reactives at large scale, or detecting the state of inertia in a distributed fashion. Marko Obrovac, PhD student in the team, works in this track, in collaboration with the LIP6 laboratory, hosted by the University Pierre et Marie Curie, in Paris.

All together, these building blocks will compose the next generation of middleware systems, able to fully leverage the Internet of Services, thanks to a programming model able to express its internal complex behaviour.

Link:
Myriads team:
http://www.irisa.fr/myriads/

Please contact:
Cédric Tedeschi
INRIA, France
Tel: +33 4 99 84 73 05
E-mail: cedric.tedeschi@inria.fr

Self-Organising Adaptive Structures: The Shifter Experience

by Carlos E. Cuesta, J. Santiago Pérez-Sotelo and Sascha Ossowski

Self-Adaptation (ie the ability to react to changes in the environment) is becoming a basic architectural concern for complex computational systems. However, it is very difficult to provide this feature by conventional means. Inspired by the behaviour of biological systems (and stem cells in particular) we define a new approach to provide multi-agent systems with a dynamic structure, effectively transforming them into self-organizing architectures.

Agreement Technologies (AT) and Agreement Computing refer to methods, techniques and tools for the development and deployment of next-generation intelligent information and software systems. These terms describe certain large-scale open distributed systems whose semi-autonomous elements interact with each other based on the notion of agreement – where these elements, often called agents, negotiate to reach both their individual and system-wide goals.

We have developed the Shifter approach as part of the AT sandbox, that provides a system with the capability of self-adaptation, ie the ability to adapt its behaviour to changes in the environment. This is a very relevant and powerful feature, but unfortunately it is also very complex and difficult to obtain by usual computational means. Just like agreements themselves, adaptations cannot be based on a closed predefined strategy – they must be emergent. As a result, the architecture of the system must itself be emergent, so we conclude that it defines a self-organizing system.

In the context of AT, the central idea is to use intelligent-based technologies to provide powerful features to conventional applications. Therefore the approach starts with a classic AI-based technology, that of multi-agent systems (MAS). However, agents are only the basic foundation – the system is setup to hide these details from the final user. In fact, the functionality is presented in the form of services.

The management of MAS is essentially a coordination problem; and several researchers have provided an enhanced approach to that problem including the notion of organizations. These are essentially structured groups of agents, which join together to achieve or maintain some long-term goal by applying a set of coordination mechanisms. In this respect, a core feature in open systems is the ability to change between coordination strategies on-the-fly, so as to successfully adapt behaviour of the system and its elements to changing situations.

The Shifter approach takes inspiration from biological systems – and in particular from cellular systems – to go beyond that setting. The core of the comparison is to consider any agent (our shifter) as a stem cell: a powerful

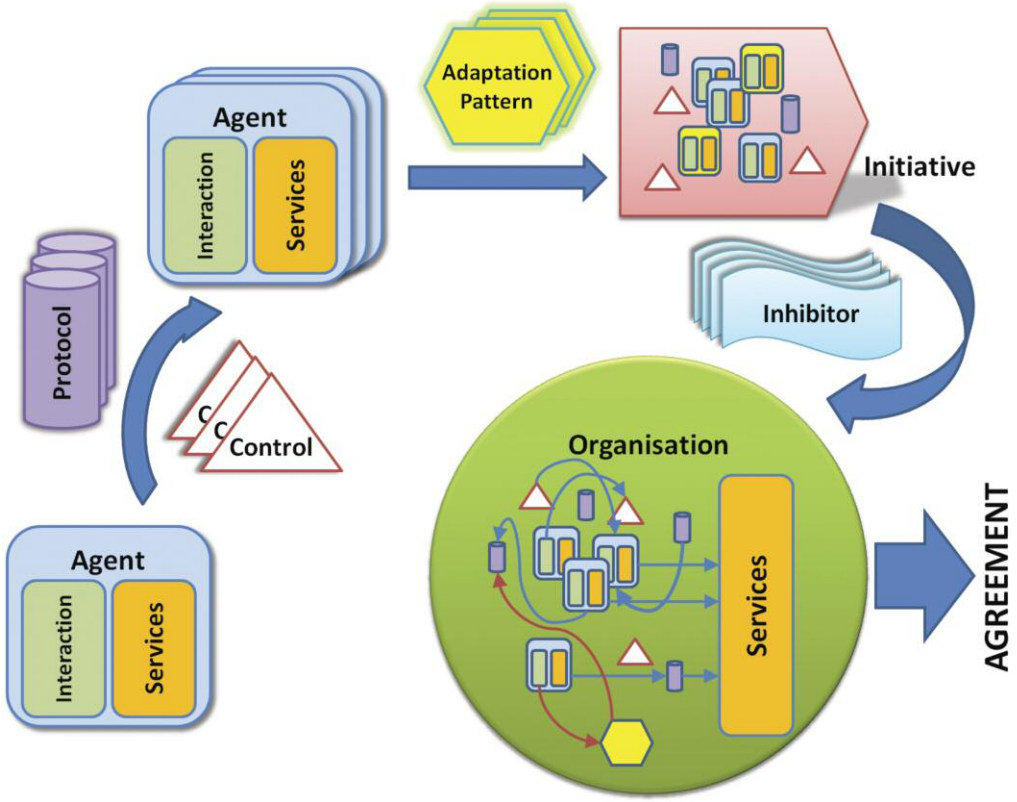


Figure 1: Lifecycle of a self-organizing structure – from a single agent to a full organization.

computational unit, able to perform a concrete functionality once it has been instructed to do so. Just like stem cells, in the beginning an agent is a neutral module, capable of transforming into whatever the system requires; once they have acquired a function, they turn into conventional cells.

We are specifically interested in the emergence of structures – ie the equivalent of the formation of biological tissues. Just like stem cells acquire their functions by contacting the cells of a certain tissue, agents learn by interacting with other agents.

Figure 1 shows the lifecycle of our self-organizing structures. The cycle begins with a single agent, capable of performing certain interactions and with the potential of exporting some services. This agent reaches the system, and initially it does not belong to any organization. However, it finds a number of predefined controls (limiting what it is able to do) and protocols (enabling it to interact to other entities). These elements "guide" the agent's interaction and enable it to maintain structured conversations with other agents, composing informal groups of agents.

At some point, an external change occurs, and the system must react with an adaptive behaviour. Of course, this is the functionality that must trigger the formation of our self-organizing structures. To be able to achieve the desired reaction, the system is provided with a number of adaptation patterns. These are neither closed strategies nor full descriptions of a reactive behaviour, but partial definitions of elements and relationships, which include enough information for an agent to learn how to perform a certain fine-grained, but relevant, behaviour. Therefore, under the influence of an adaptation pattern, certain agents within the group acquire specific functions, and begin to form an actual structure: this is what we call an initiative.

The analogy is particularly relevant here: if the process continues with no additional control, cells continue growing, and evolve into cancer – however, metastasis is avoided by reacting to existing inhibitors. Similarly, when the initiative is already fulfilling all the required functions – every service is being served by some agent – our inhibitors transform the initiative into a full organization.

These organizations are adaptive by formation, and are themselves able to evolve and participate in larger agreements – which could trigger the formation of yet another composite organization. In summary, the process guarantees that the result is indeed an adaptive agreement architecture.

Ongoing research continues, exploiting and developing this infrastructure by providing new adaptation patterns and examining their consequences in real case studies.

Links:
Agreement Technologies (CONSOLIDER Project):
http://www.agreement-technologies.org

COST Action IC0801 (Agreement Technologies):
http://www.agreeement-technologies.eu

Please contact:
Carlos E. Cuesta, J. Santiago Pérez-Sotelo, Sascha Ossowski
Rey Juan Carlos University, Madrid, Spain
E-mail: carlos.cuesta@urjc.es, josesantiago.perez@urjc.es, sascha.ossowski@urjc.es

Alchemy of Services

by Claudia Di Napoli, Maurizio Giordano and Zsolt Németh

What do chemical reactions and service compositions have in common? Not much at first sight. But if we imagine the composition of services as a self-evolving autonomic process then they show notable similarities to the way chemical reactions occur. Taking reactions as a metaphor, there is an ongoing effort to discover the power of chemical modelling studied within the framework of a service composition problem.

The Internet of Services (IoS) will change the way enterprises do business, since it will embrace not just information and content but also services and real world objects. In alignment with the paramount importance of the service oriented computing paradigm in shaping the future, the "Software Services and Systems Network" (S-Cube, FP7/2007-2013 under grant agreement 215483) is aimed at establishing a unified, multidisciplinary research community and shaping the software service based Internet which will underpin the whole of our future society. S-Cube integrates three research communities: Software Engineering, Grid/Cloud Computing and Business Process Management, attempting to integrate the research traditionally fragmented into three separate layers: service infrastructure, service composition & coordination and business process management. The overall emphasis is on novel service functionalities, especially adaptation and pro-active techniques, methodologies for engineering and adapting service-based systems and end-to-end quality provisioning and SLA-Compliance.

According to the S-Cube vision, the service oriented computing paradigm enables service providers to dynamically integrate services in a large-scale and heterogeneous environment whereas service requesters can adjust and compose services according to their actual needs. Thus, Service Based Applications (SBAs) are composed of a number of possibly independent services, available in a network, which perform the desired functionalities. It is likely that more service providers can provide the same functionality at different conditions referring to non-functional characteristics of a provided service, like price, time to deliver, and so on. These may change in time depending on provider policies, and as such they cannot be advertised together with the service description nor planned in the composition design. It therefore becomes necessary to organize compositions of services on demand in response to dynamic requirements and circumstances.

Within the S-Cube research activity we modelled the problem of selecting services necessary for delivering an SBA required by a user as a nature metaphor. In our scenario an SBA request is an abstract workflow (AW) specifying the functionality of each component, the dependence constraints among them, and some user-preferred non-functional characteristics of the whole composition. Providers, able to provide the required AW functionality, issue service offers that specify a service instance together with the value of non-functional characteristics it can provide the service with. More offers for the same functionality can be available, and additional offers that should be taken into account can become available during the selection process.

We envision a chemical solution in a flask where both activities of the AW (service requests) and all service offers

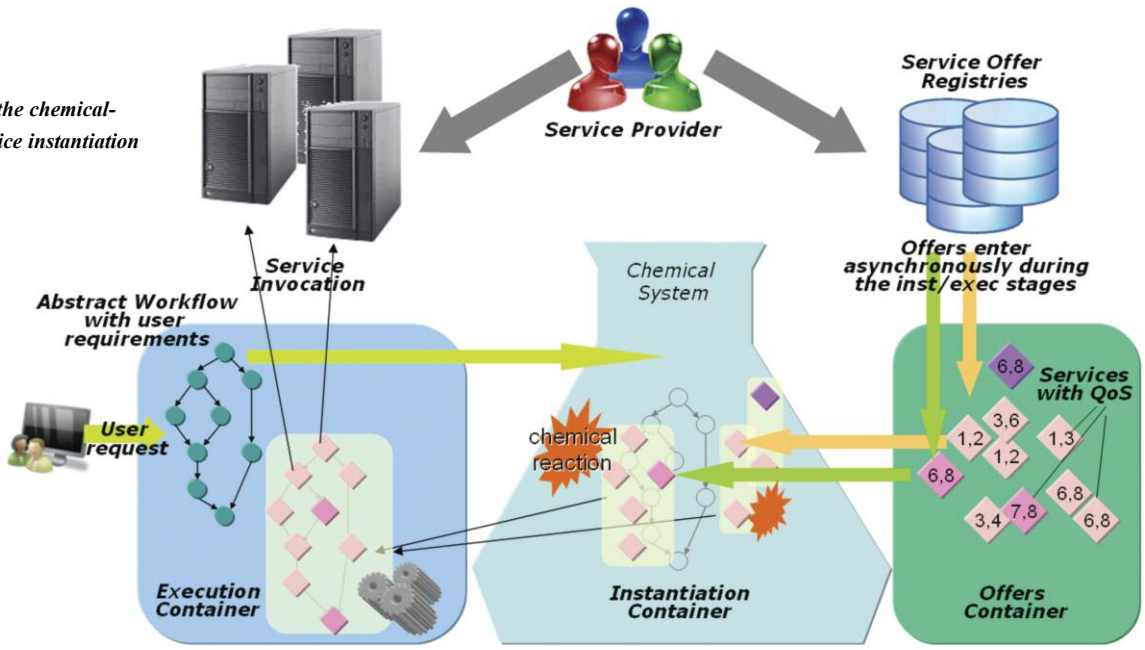


Figure 1: the chemical-based service instantiation process.

are molecules. Aggregation constraints and non-functional user-requirements on services are expressed as chemical properties, i.e. chemical reaction rules. We use the chemical analogy as a modelling paradigm and our approach differs significantly from computational chemistry that faithfully simulates chemical reactions. The chemical metaphor can be expressed in the gamma-calculus, a declarative formalism developed for grabbing the notion of concurrent indeterministic multiset rewriting. We implemented our model in the Higher Order Chemical Language (HOCL), a derivative of the gamma-calculus.

The proposed approach allows the capture of service selection in the context of SBAs in terms of local reaction rules that yield aggregated molecules. Once an aggregation of services is computed the chemical solution reaches an inert state, but it can be re-activated when new offers are available or already existing offers are changed. New offers are new molecules that may form a new aggregation or alter existing molecules, so that the system can exhibit an adaptive behaviour. Similarly, control can be added in the form of molecules, something similar to catalysts and inhibitors. All is dependent on how the service offers and needs are translated into chemical properties (chemical aggressiveness).

This model does not rely on any centralized and/or coordinated control, or on any predefined sequences or patterns. The process just follows some (high-level) policies in the same way that reactions obey the general laws of nature. With this greater flexibility and dynamicity we expect that the behaviour of molecules, together with the overall constraints of the aggregation may enable adaptation of the system to different configurations that are not planned in advance. Applying the chemical metaphor to the problem of selecting service instances allows the service selection process to be modelled as an “evolving” and always running mechanism that can adapt to environmental changes as they occur, so providing adaptability to changes in non-functional characteristics.

Our prospective is to further investigate the proposed approach in order to answer the following questions: is it possible to model the problem of finding an optimal solution to the service composition problem just like a chemical reaction would reach minimum energy? Is it possible to establish the chemical properties so that the composition procedure evolves into a well defined and desired state? We envision that a chemical-based approach for selecting services to form an SBA is a viable approach to answer these questions. Furthermore, the chemical-based instantiation process may run concurrently with a workflow enactment engine thus providing the possibility to interleave the selection process with the enactment. In such a way it is possible to consider new offers, as soon as they appear in the system, that may produce sub-parts of instantiated workflows (partially instantiated workflows) providing missing service instances that were not available before the execution started.

Link:
http://www.s-cube-network.eu/

Please contact:
Claudia Di Napoli,
Maurizio Giordano
Istituto di Cibernetica “E. Caianiello” - CNR, Italy
E-mail: c.dinapoli@cib.na.cnr.it, m.giordano@cib.na.cnr.it

Zsolt Németh
SZTAKI, Hungary
E-mail: zsnemeth@sztaki.hu

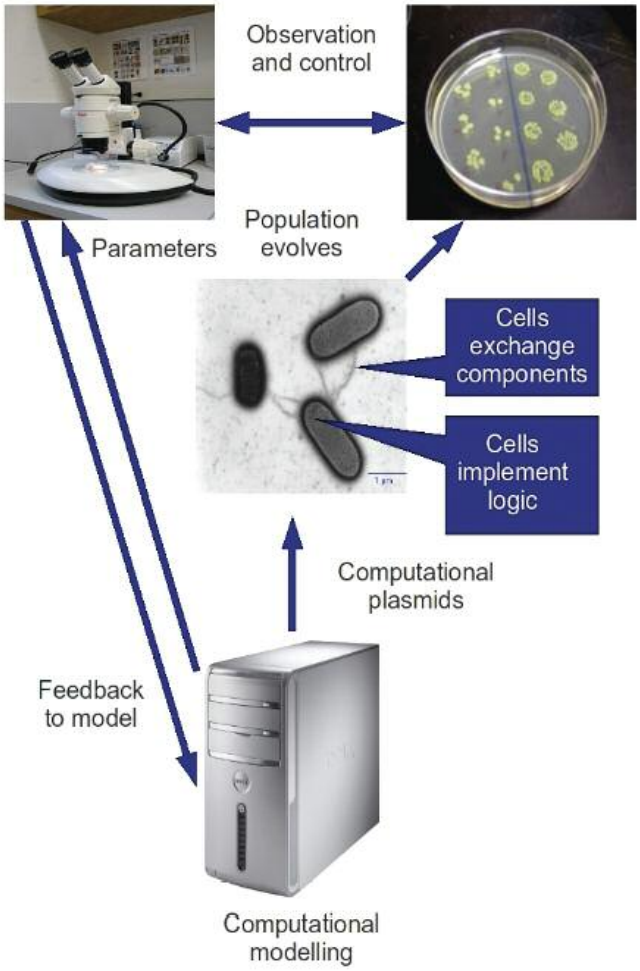
BACTOCOM: Bacterial Computing with Engineered Populations

by Martyn Amos and the BACTOCOM consortium

Various natural computing paradigms inspired by biological processes, such as artificial neural networks, genetic algorithms, ant colony algorithms, have proved to be very effective and successful. However, we can go one step further: instead of developing computing systems inspired by biological processes, we can now directly use biological substrates and biological processes to encode, store and manipulate information. Early implementations of bio-computing used DNA as a miniaturised “storage medium”, but we go beyond this, to harness the “biological nanotechnology” available inside every living cell.

The main objective of the ongoing BACTOCOM project is to build a simple computing device, using bacteria rather than silicon. Microbes may be thought of as biological "micro-machines" that process information about their own state and the world around them. By sensing their environment, certain bacteria are able to move in response to chemical signals, allowing them to seek out food, for example. They can also communicate with other bacteria by leaving chemical trails or by directly exchanging genetic information. We focus on this latter mechanism.

Parts of the internal "program" of a bacterial cell (encoded by its genes and the connections between them) may be "reprogrammed" in order to persuade it to perform human-defined tasks. By introducing artificial "circuits" made up of genetic components, we may add new behaviours or modify existing



functionality within the cell. Existing examples of this include a bacterial oscillator, which causes the cells to periodically flash, and cell-based pollution detectors that can spot arsenic in drinking water. The potential for bio-engineering is huge, but the process itself is made difficult by the noisy, "messy" nature of the underlying material. Bacteria are hard to engineer as they rarely conform to the traditional model of a computer or device with well-defined components laid out in a fixed design.

We intend to use the inherent randomness of natural processes to our advantage, by harnessing it as a framework for biological engineering. We start with a large number of simple DNA-based components taken from a well-understood toolbox, which may be pieced together inside the cell to form new genetic programs. A population of bacteria then absorbs these components, which may (or may not) affect the behaviour of the cells. Crucially, the core of our bacterial computer is made up of engineered *E. coli*. microbes that can detect how well they are performing, according to some external measure, such as how well they can flash in time with light pulses.

We engineer a set of computational plasmids; circular strands of DNA representing "components", which may be combined together within the cell to form a simple logical circuit. These components may be exchanged between individual bacteria via the process of conjugation; the transfer of genetic material via direct cell-cell contact. By introducing large numbers of these computational plasmids, we initialize the system. Over time, the bacteria integrate the components into their genomes, thus "building" logical circuits. The "output" of these circuits is measurable, and by defining "success" in terms of correlation with a desired signal profile, we allow successful components to flourish via a process of selection. By controlling the desired signal profile, we direct the “evolution” of the population towards novel, robust computational structures.

By performing massively-parallel bacterial random search, we will quickly obtain functional devices without "top down" engineering. There are many potential benefits to this work, from both a biological and computing perspective. By "evolving" new functional structures, we gain insight into biological systems. This, in turn, may suggest new methods for silicon-based computing, in the way that both evolution and the brain have already done. In building these new bio-devices, we offer a new type of programmable, microscopic information processor that will find applications in areas as diverse as environmental sensing and clean-up, medical diagnostics and therapeutics, energy and security.

The BACTOCOM project is a three-year programme, funded by the European Commission FP7 FET Proactive initiative: CHEM-IT (Bio-chemistry-based Information Technology). It began in February 2010, and is coordinated by Martyn Amos of Manchester Metropolitan University, UK. Other partners include, Universite d'Evry Val d'Essonne-Genopole®-CNRS (France), Universidad Politécnica de Madrid and University of Cantabria (Spain), Interuniversitair Micro-Electronika Centrum (IMEC, Belgium) and Charite - Universitätsmedizin Berlin and the Technical University Munich (Germany).

Link:
BACTOCOM project website:
http://www.bactocom.eu

Please contact:
Martyn Amos
Novel Computation Group
Manchester Metropolitan University
E-mail: M.Amos@mmu.ac.uk

Bio-Sensors: Modelling and Simulation of Biologically Sensitive Field-Effect-Transistors

by Alena Bulyha, Clemens Heitzinger and Norbert J Mauser

We present modelling and simulations of Bio-FETs (Field-Effect-Transistors), a complex multi-scale system where a semiconductor device is coupled to a bio-sensitive layer that detects bio-molecules such as DNA in a liquid. Our mathematical modelling yields qualitative understanding of important properties of Bio-FETs and helps to provide high performance algorithms for predictive simulations.

Recent experiments have shown the possibility of detecting bio-molecules in a liquid by the effect of their intrinsic charge on the conductance of a semiconducting nano-wire transducer. Such sensor devices are fast, cheap and label-free. Figure 1 shows a schematic Bio-FET, which consists of a semiconducting transducer separated by an insulator layer (typically silicon dioxide or nitride) from the biological recognition element (receptors or probe molecules) that surrounds the transducer immobilized to the surface, consisting of antibodies, proteins, enzymes, nucleic acids or living biological systems. The transducer immerges into an electrolyte (aqueous solution of NaCl) that contains the analyte, i.e. the target molecules that we want to detect, such as DNAs, antigens, proteins. The principle of Bio-FETs is actually simple: when the analyte bio-molecules bind to the surface receptors, the charge distribution at the surface changes, which modulates the electrostatic potential in the semiconductor and thus its conductance which can be easily measured. Since the device detects a specific substance, the change of the conductance yields the concentration in a rather direct way.

The modelling of such Bio-FET sensors must take into account the electrostatics and geometry of the liquid, the probe and the target molecules in the boundary layer, the binding efficiency of the probes and targets, the electrostatics and the conductance of the semiconducting transducer and device geometry. Note that the bio-molecular and the nano-electronic part define very different length scales, they have to be considered separately and then coupled in a self-consistent manner.

As a mathematical model for the transport of electrons and holes inside the transducer we use the drift-diffusion equation coupled to the Poisson equation. The standard continuum model is the mean-field Poisson equation, in which the free charges are treated as points, included using Boltzmann statistics. The classical Poisson–Boltzmann theory is successfully used to study the planar electric double layer and the electrolyte bulk.

In our multiscale problem the original Poisson equation is replaced by a homogenized problem consisting of the Poisson equation with two interface conditions at the surface. The values that determine the interface conditions are easily evaluated from the simulations. The boundary conditions for bio-sensors include the selectively adsorbing surface with probe molecules or purely reflective (inert) walls.

A key aspect of the modelling is the calculation of the charge distribution in bio-functionalized surface layers. Both electrostatic and the hard-sphere collisions are sensitive to ion size. Since the electrolyte is usually buffered, it is essential to consider not only mixed-size, but also mixed-valence ionic systems. Therefore the radius and valence of the ions are specified as input parameters.

Since the applied voltage between electrodes and the bulk concentrations of

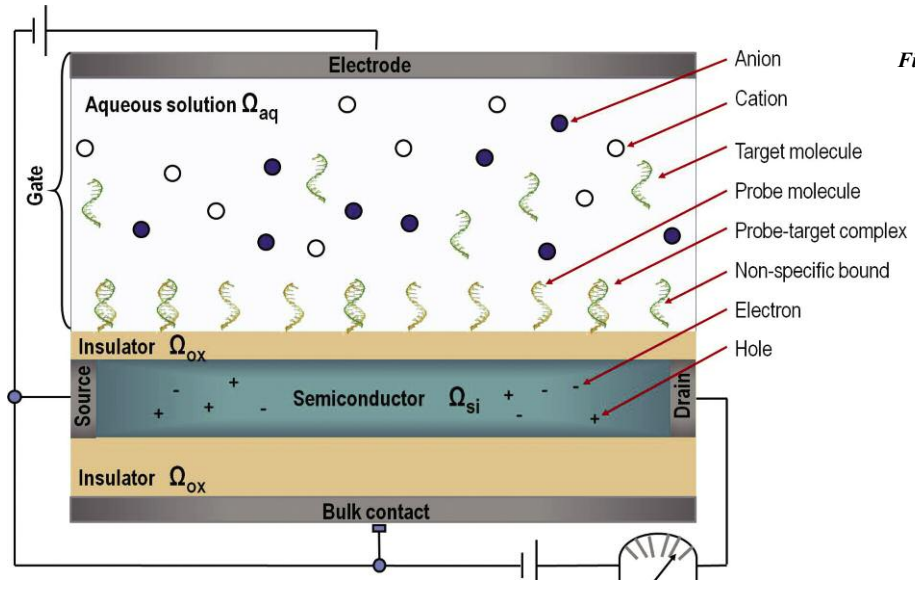


Figure 1: Schema of a Bio-FET sensor.

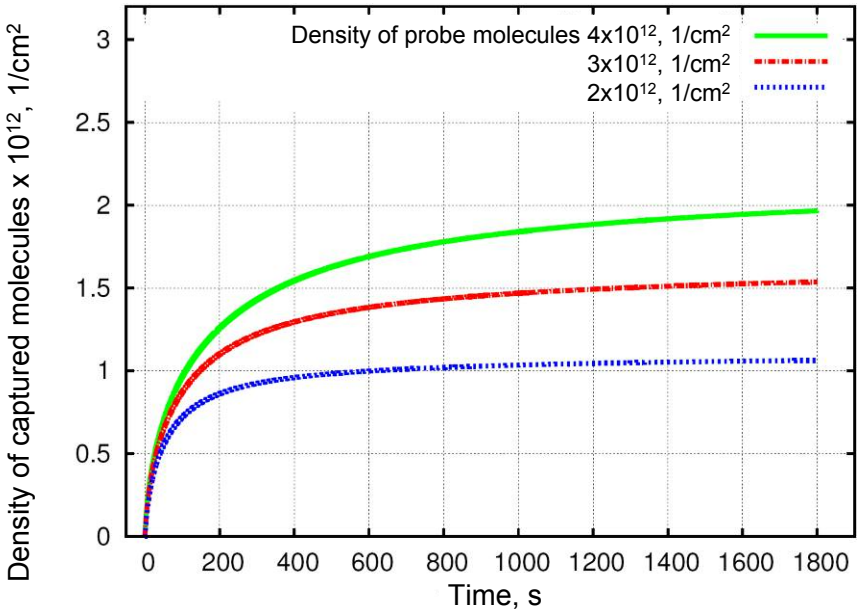


Figure 2: Simulation results of reaction-diffusion problem for density of probe-target complexes obtained at different probe densities. A higher probe density (green lines) leads to a faster binding at the beginning of the simulated process and to a decrease of total analyte concentration in the solution (not shown here). That results in a lower binding efficiency of captured analyte at higher probe density. Thus, at t=1400s the binding efficiency will be 48%, 50%, and 52% for probe densities of $4x10^{12}$ (green), $3x10^{12}$ (red) and $2x10^{12}$ (blue) molecules per cm^2, respectively.

the ions are controlled in experiments, their influence on the ionic concentrations also has to be investigated. The Metropolis Monte Carlo (MMC) algorithm in the constant-voltage ensemble is the appropriate numerical method. We have extended it to investigate the ionic concentrations near the groups of charged objects with various geometries and sizes, representing, for instance, DNA strands in different orientations.

Another crucial aspect of the modelling is the simulation of the transport of target molecules in the analyte solution to the active sensor area. There are several mechanisms:

a) Diffusion. b) Convection. c) in addition, the pump is essential for the fast response times. d) Migration: The movement of charged particles in response to a local electric field. Its contribution to the total flux is proportional to the charge of the ions, the ion concentration, the diffusion coefficient, and the strength of the electric field gradient, which is induced by the ion and by the applied external potential.

The internal electrical potential is obtained via Poisson equation. The velocity field is modelled by the Navier-Stokes equations. Note that diffusivity depends in general on the type (size and shape) of the molecules.

All these processes are taken into account in the algorithms for the diffusion-convection-migration (DCM) problem with chemical reactions near the functionalized surface.

The whole simulation consists of different steps as follows:

1) DCM is solved to find a concentration of analyte molecules for every space point at a time.

2) The target molecules, which have reached the functionalized surface, take part in the chemical reactions described by ordinary differential equations for specific and non-specific binding. By solving them we find a distribution as well as binding efficiency of captured molecules. The density of probe-target complexes for varying density of probe molecules is shown in Figure 2 as a function of time.

3) Then the MMC is applied to find the ionic concentrations near the surface and within the intermolecular space. At first the simulation is performed with the surface that is functionalized with probe molecules, which have a known density, and then the MMC is applied to the probe-target complexes with the same density.

4) For coupling atomistic and continuum models, microscopic charge distributions from the MMC solver are recalculated to the macroscopic surface charge densities and to the macroscopic dipole moment densities. They are weighted by the binding efficiency and used as interface conditions in the homogenized Poisson equation.

5) Finally the Poisson equation provides the voltage for MMC and external potential for migration model.

A self-consistent loop between the micro- and macroscopic simulations provides the basis for the quantitative description of BioFETs and their predictive simulation.

Acknowledgement: this work was supported by the Austrian Science Fund (FWF, projects W8 and P20871), the Viennese Fund for Technology and Research (WWTF, project MA09-28) and the European Commission (project MEST-CT-2005-021122 “DEASE”)

Link:
http://www.wpi.ac.at

Please contact:
Norbert J Mauser
Wolfgang Pauli Institut c/o Univ. Wien
E-mail: norbert.mauser@univie.ac.at

Clemens Heitzinger
WPI and DAMTP, Univ. Cambridge
E-mail: clemens.heitzinger@univie.ac.at

Self-Organizing P2P Systems Inspired by Ant Colonies

by Carlo Mastroianni

We show how bio-inspired algorithms can be used to enhance the flexibility and efficiency of peer-to-peer computer networks and present Self-Chord, a peer-to-peer system in which resources are distributed, in an adaptive and semantic-aware fashion, by means of statistical algorithms inspired by the behavior of ant colonies. This strategy enables the efficient execution of complex queries, improves the load balance among peers, and strengthens the system's ability to self-organize and rapidly adapt to environmental changes.

Modern peer-to-peer (P2P) systems are based on a structured overlay, meaning that peers are organized in accordance with a predefined logical structure – ring, multi-dimensional grid, tree – and resources are assigned to peers with a precise strategy. This allows discovery requests to be driven, exploiting P2P interconnections, directly to the peers that store the desired resources. This type of organization is adopted by all the most popular P2P platforms (Kademlia, BitTorrent, Freenet), and recently also by Cloud companies for their distributed storage systems (for example, the Dynamo system adopted by Amazon).

Structured P2P systems are generally based on Distributed Hash Tables (DHT), whose purpose is to assign keys to resources, and indexes to peers, by means of hash functions. Each peer is responsible for a portion of the key space, and is required to manage the keys belonging to this portion. However, the use of hash functions has an important drawback: since similar resources are mapped to completely different keys, they are generally assigned to peers that are located far from each other in the overlay. This hinders the efficient execution of queries for resources having similar characteristics, or "range" queries.

At the ICAR-CNR Institute, in collaboration with the Politecnico di Torino, we have devised a new technique to implement structured P2P systems without using DHT functions. Instead of being computed with a hash function, resource keys may be given a semantic meaning, for example the value of a resource attribute. In this way, the keys of similar resources can be assigned to the same or neighbour peers, thus enabling the efficient execution of range queries. The technique is based on statistical operations of mobile agents whose behaviour is inspired by ant colonies, and follows the swarm intelligence paradigm. Ants hop from peer to peer, pick/drop resource keys, and sort them on the underlying P2P structure. Sorting of keys ensures their prompt discovery.

Ants Swarming in a Ring: the Self-Chord System

This ant-inspired approach has been adopted in the Self-Chord P2P system. Self-Chord uses the ring-shaped overlay of Chord, the forefather of structured P2P systems, to establish P2P interconnections, but distributes resource keys among peers using the operations of ant-inspired mobile agents. The underlying principle of this mechanism is illustrated in Figure 1. In this example, keys can be assigned integer values in the range [0..99], and the key space is toroidal, so that key 0 is the successor of key 99. Each peer computes its centroid as the key value that minimizes the sum of the distances between itself and the keys stored in the local area. In the example, an ant arrives at the peer with centroid C=30, and picks key 55, because its value is dissimilar to the centroid. Actually, the pick operation is subject to a Bernoulli trial, whose success probability is inversely proportional to the distance between key and centroid. The agent carrying the picked key exploits the long distance links of the underlying Chord structure, hops to a region of the ring where peers are supposed to have centroid values close to the key, and then tries to drop the key in this new region. Note that these operations assume that keys and centroids are already sorted in the ring. The power of the ant algorithm is that, by making this assumption, the keys will actually be ordered, even when starting from a completely disordered network. In stable conditions, the sorting of keys guarantees their logarithmic discovery. The base principles for this behavior are the self-organizing

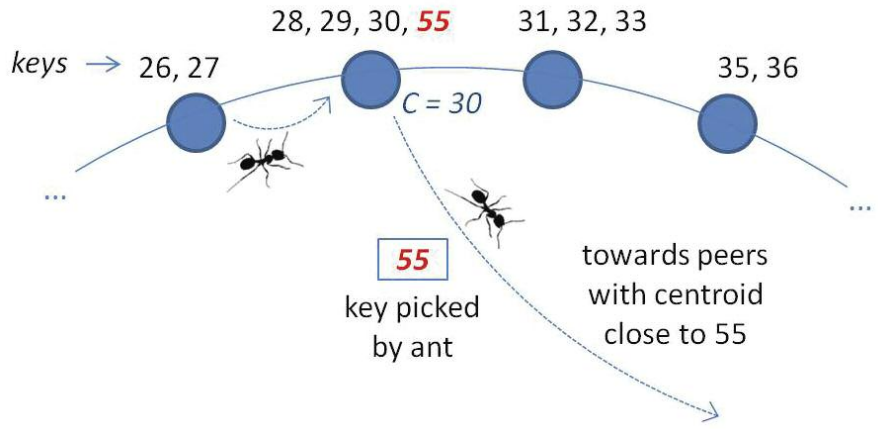


Figure 1: Example of a Self-Chord operation. A mobile agent arrives at a peer with centroid C=30, picks key 55, and then hops to a region of the ring where peers are supposed to have centroids close to 55.

nature and the positive feedback mechanism of ant algorithms.

In addition to serving range queries, this approach has further advantages:
- the range of values that can be assigned to keys is arbitrary
- the keys are fairly balanced among peers. In DHT-based networks, this feature is hindered by the non uniform distribution of resources and corresponding keys
- the network traffic is stable because it only depends on the frequency of ant movements. In DHT-based networks, the traffic is strongly affected by the frequency of peer connections and reconnections.

Ants Swarming in Multi-Dimensional and Hierarchical Structures

The ant approach can be adapted to any kind of overlay. In particular, we are analysing its application on multi-dimensional and hierarchical structures. A multi-dimensional overlay fits very well to situations in which resources are described by multiple and independent attributes: for example, computers may be described by their amount of memory, CPU speed, number of cores, etc. The ant-inspired approach allows resources to be described by multi-dimensional keys, corresponding to the attribute values, and keys to be sorted over the multi-dimensional structure. This enables the efficient execution of multi-attribute range queries, a sophisticated functionality that is very challenging in DHT-based systems.

The second case under study is when resources are described by hierarchical keys: this may be the case of distributed XML databases, in which documents are built in accordance with a hierarchical schema. For this kind of application, an appropriate overlay is that of Pastry. In Pastry, P2P interconnections are organized in a logical tree, and they allow agents to jump between peers whose indexes have a common prefix of any specified length. Mapping XML instances to this structure means that it will be possible to efficiently serve complex XML queries.

Links:
http://self-chord.icar.cnr.it
http://en.wikipedia.org/wiki/Distributed_hash_table
http://en.wikipedia.org/wiki/Swarm_intelligence

Please contact:
Carlo Mastroianni
ICAR-CNR, Italy
Tel: +39 0984 831725
E-mail: mastroianni@icar.cnr.it

Dialogue-Assisted Natural Language Understanding for a Better Web

by Mihály Héder

By studying and improving the process of digital content creation, we can develop more intelligent applications. One promising step ahead is to acquire machine representation of content as early as possible - while the user is still typing and is available to answer questions.

Internet triggered a major revolution in everyday communication. The basic goal has not changed- to reach other people and to share our ideas- but everything else is different.

Computers, as mediators, have been incorporated into communication channels and users turn directly to them, and indirectly to other users when they need information. Clearly, the better the computers understand the content, the more useful and convenient they will become. However, to achieve some sort of understanding, they first need at least 1) an adequate machine representation of the content and 2) background knowledge. In this article, I will present a means of achieving the former.

In general, the life cycle of digital content can be divided into three stages: 1) the creation and formatting of content carried out by the user; 2) the attempt to create a machine representation of the content, carried out by indexers, the information extractor and a text mining software (typical components of a search engine); and finally, 3) the content can be consumed by other users (see Figure 1).

We have to face the fact that the second step of this process is very hard to carry out in a fully automated manner, as it would require unassisted natural language understanding to achieve the best results. Fortunately, when the content is yet to be written, we have an alternative option.

In the frame of a project in SZTAKI, we try to merge the first two phases of the content creation process detailed above. Our experimental software processes content on the fly while the user is still typing, and tries to ask relevant questions from him/her using everyday language. The aim of these questions is to clarify what the machine representation of the text should be (see Figure 2). While there are a multitude of semantic annotator tools, we think that the dialogue-assisted input method makes our solution a rather unique one. Also, this same property is the key to enabling lay users to create semantic annotations.

Our system consists of a rich text editor built around TinyMCE which is capable of visually annotating the content, and presenting questions/suggestions to the user. On the server side, we have a UIMA-compatible text processing system which relies on various UIMA Analysis Engines. One of these is the Magyarlanc, a tokenizer, lemmatizer and part of speech (POS) analyser for Hungarian. We also have a lan-

guage recognizer, an English POS tagger, a named entity recognizer, and Hitec3, a hierarchical document categorizer integrated.

We have two applications of this system and we plan to develop more. One is a complaint letter analyser, which is being developed with the help of a corpus of 888 letters written to the Hungarian Ministry of Justice. These letters normally tackle diverse issues and in many cases they are unclear and unstructured, so their autonomous processing as such has not been effective. We were able to improve the quality of their processing with semi-autonomous matching of scripts and frames, using the support of dialogues. For more information, see the links at the end of this article.

The other application is the "Sztakipedia" project, which aims to develop a Wikipedia editor. The tool will have an intuitive web interface with rich text editor, which supports the user with suggestions to improve the quality of the edited article.

Some of the vital aspects of this content creation process are already working. With the help of a Hitec3 instance, the software is able to suggest categories; this software was trained on the entire content of the Hungarian Wikipedia articles. It can also suggest "InfoBoxes", which are table-like descriptions of the properties of common entities like "people" and "cities". Furthermore, the software can offer a number of links leading to other Wiki articles by the analysis of words in the currently edited article. In addition to this, the user can ask for links in connection with a given phrase; in this case, our tool starts a search in the background, using the Wiki API and formulates suggestions from the search result.

In spite of the fact that these functions are very promising, we have many problems that we have to overcome. Probably the hardest one is that while our tool is able to generate proper wiki markup, this format itself does not support every type of semantic annotations that we need. We have to consider other questions as well, for example, whether it is important to store meta-information about the user's answers to our questions and suggestions, or what to do with "negative" answers, for example when a given InfoBox is not applicable on a given article.

We hope that we can start public tests in 2011 with this novel tool. Further details can be found at the project website.

Links:
Complaint letter project: http://dialogs.sztaki.hu
Sztakipedia project: http://pedia.sztaki.hu

Please contact:
Mihály Héder
SZTAKI, Hungary
Tel: +36 1 279 6027
E-mail: mihaly.heder@sztaki.hu

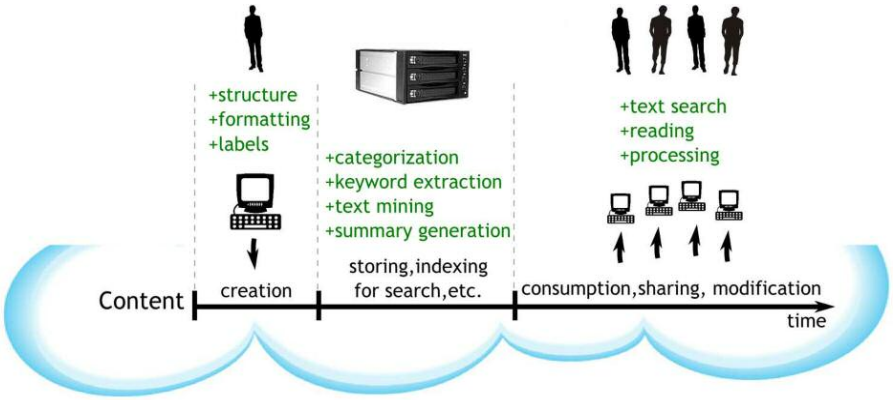


Figure 1: The average life cycle of the digital content.

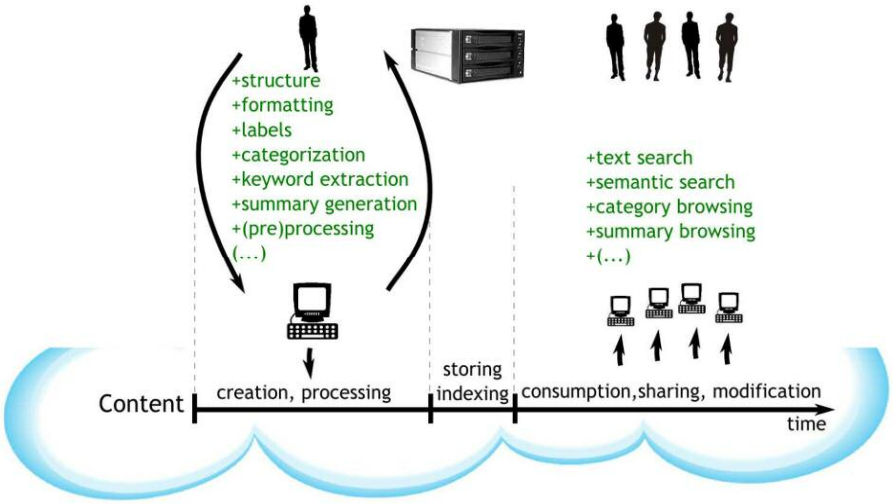


Figure 2: The proposed method of content creation.

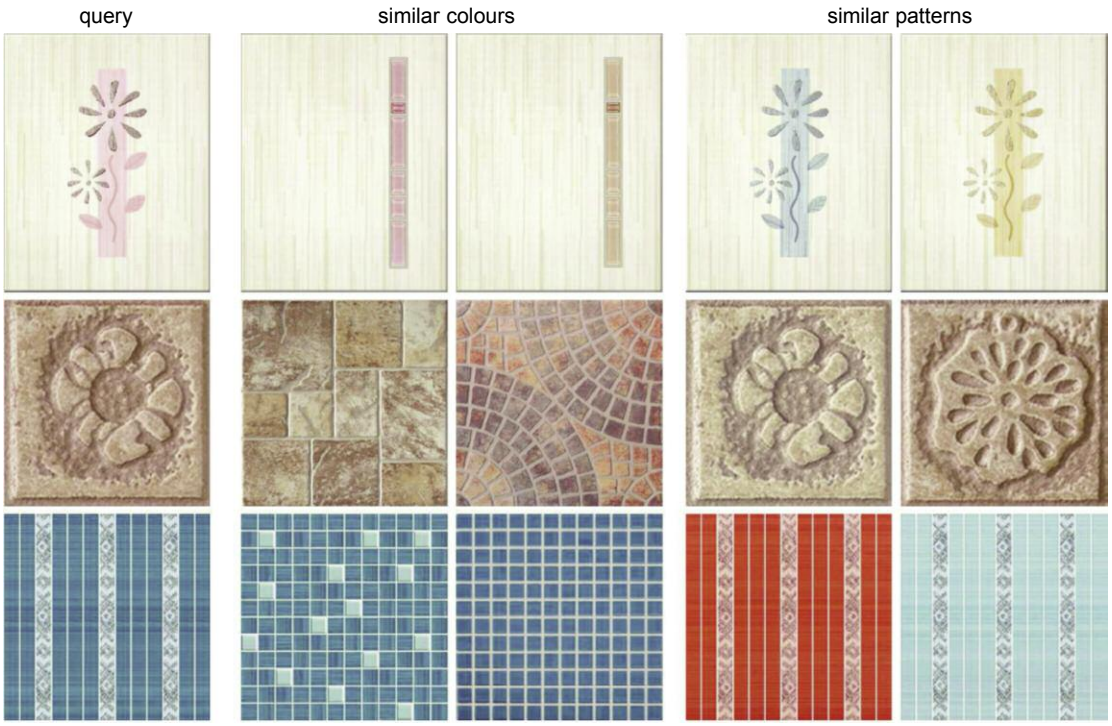


Figure 1: The system offers catalogue tiles, which have similar colours or patterns (characteristics) as the query tile. The images are courtesy of Sanita.cz.

Content-Based Tile Retrieval System

by Pavel Vácha and Michal Haindl

Recent advances in illumination invariance and textural features were utilized in the construction of a content-based tile retrieval system, which eases laborious browsing of large tile catalogues. Regardless of whether a user is choosing tiles for their house or designing a prestigious office building, this computer-aided consulting system will help to select the right tiles by suggesting tiles which have similar colours and / or patterns as some other tiles that the user likes. The performance of the system was verified on a large commercial tile database in a psycho-physical experiment.

The tile retrieval system is based on an image representation by an underlying multi-spectral Markov random field. Spatial relationships within the image are modelled by a special type of Markov model, which allows efficient and analytical estimation of its parameters, avoiding the usual time-consuming Monte-Carlo approach. Tile patterns are represented by estimated model parameters, which are transformed into our illumination invariant textural features. These features are unaffected by illumination colour and robust to illumination direction variations, therefore arbitrary illuminated tiles do not negatively influence the retrieval result. To allow separate retrieval of similar patterns and / or colours, the system utilizes colour representation by marginal cumulative histograms.

The utilized features (colour invariants) are capable of representing colour patterns with same luminance and still remain robust to illumination colour, which is in contrast with a usual texture representation by gray-value textural features. The performance of our colour invariants was successfully verified using MUSCLE ERCIM working group cooperation utilizing the Amsterdam Library of Textures (ALOT), which contains images of over two hundred natural and artificial materials acquired in variable conditions.

The tile retrieval system was verified in a visual psycho-physical experiment on a large commercial tile database containing several thousand images. In the experiment, the retrieved tiles were blindly ranked by volunteers as: very similar, similar, less similar, and dissimilar. In summary, 76% of retrieved images were considered to be very similar or similar, while only 12% were marked as dissimilar.

The system can be used in the following ways: A user can take a photo of old tile lining and find a suitable replacement for broken tiles from recent production. During browsing of digital tile catalogues, the system can offer tiles with similar colours or patterns as the selected tile, which could be integrated into an internet tile shop. Alternatively, the tiles can be clustered according to visual similarity and consequently, digital catalogues can be browsed hierarchically through the representatives of visually similar groups. In all cases, the system benefits from its robustness to illumination changes and possible noise degradation.

The presented retrieval system is not limited to tile images and it can be used with other kinds of image, where the visual structure and colour are important properties. Thus other possible applications in the home decor industry include retrieval of similar textiles / cloths and wallpapers. An interactive demonstration is available online.

Link:
http://cbir.utia.cas.cz/tiles/

Please contact:
Pavel Vácha
CRCIM (UTIA), Czech Republic
Tel: +420 2 6605 2365
E-mail: vacha@utia.cas.cz

Intelligent Design of Multi-Device Service Front-Ends with the Support of Task Models

by Fabio Paternò, Carmen Santoro and Lucio Davide Spano

We present a novel environment that supports the design of multi-device service-based interactive applications by using several user interface abstraction levels and utilizing the composition of annotated services.

Web services are increasingly used to support remote and distributed access to application functionalities, thus enabling a large gamut of interactive applications. However, when the user support (the service front end) is developed after delivering the Web services, it is often based on ad-hoc solutions that lack generality and do not consider the user viewpoint, thus providing front-ends with low usability.

BPMN (Business Process Modelling Notation) and BPEL (Business Process Execution Language) -based approaches are often used in Service–Oriented Architecture (SOA) efforts, but these mainly focus on direct service composition in which the output of one service acts as input for another, creating more complex services. Thus, they provide little support to the development of applications that interact with the users and perform service composition by accessing various services, processing their information and presenting the results to the end users.

One of the main advantages of logical User Interface (UI) descriptions is that they allow developers to avoid dealing with a plethora of low-level details associated with UI implementation languages. Our objective is to provide designers, who want to exploit the potential of Web services in their interactive applications, with a systematic approach that effectively addresses the specific issues raised by interactive applications when they are accessed through multiple devices. The method is based on the use of logical user interface descriptions and is also accompanied by an automatic tool (MARIAE, Model-based lAnguage foR Interactive Applications Environment), which supports all the phases. The approach uses different UI abstraction levels (task, abstract interface, concrete interface), which can also use additional UI information associated with web services (so-called annotations).

Task models describe the various activities that are supported by an interactive application, together with their relationships, through a number of relevant concepts. We describe tasks by exploiting the ConcurTaskTrees (CTT) notation, which is widely used thanks to the availability of the associated public tool (CTT Environment). Using MARIAE, it is possible to establish an association between some elementary tasks in the task model (namely, the tasks that cannot be further decomposed) and the corresponding operations specified in the Web services. This association, which involves only system tasks (namely, the tasks that are carried out by the application) is facilitated in CTT because different allocations of tasks are represented differently and therefore system tasks are easy to identify.

Provided that a suitable granularity is used to specify the task model, this association has the advantage of making the task

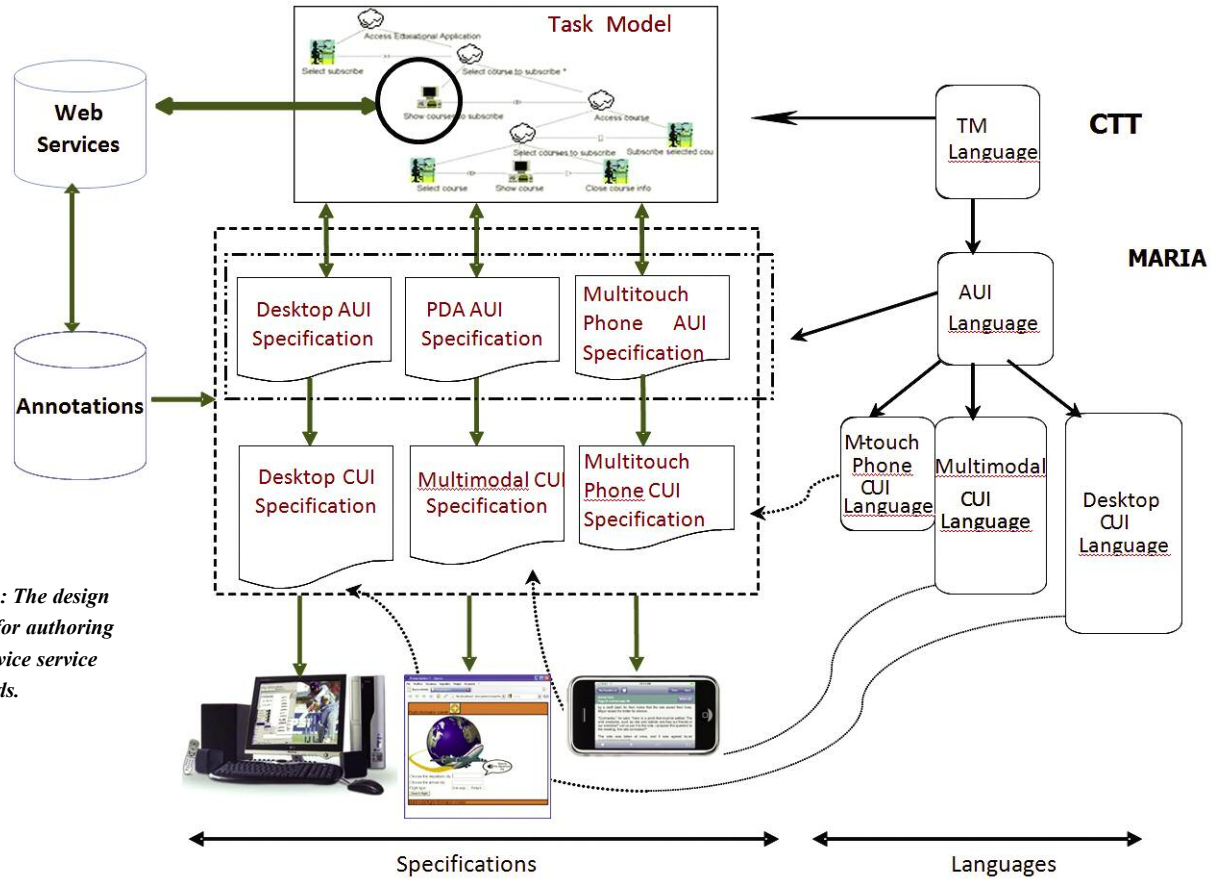


Figure 1: The design process for authoring multi-device service front-ends.

model temporal relationships automatically and consistently inherited by the associated Web service operations. This is important because task model relationships should be derived taking into account the user's perspective. Once the task model and Web services are connected, a first draft of an abstract UI description can be generated and then further edited by designers; when a satisfactory customization is reached, it can be refined into a concrete, platform-dependent one.

Designers can also include annotations associated with Web services, which provide (also partial) hints about the possibly related UIs. At the abstract UI level, the annotations can specify grouping definitions, input validation rules, mandatory/optional elements, data relations (conversions, units, enumerations), and languages. At the concrete UI level, the annotations can provide labels for input fields, content for help, error or warning messages, and indications for appearance rules (formats, design templates etc.).

When designing a specific multi-device application, the models created with device-independent languages should also take into account the features of the target interaction modality. Thus, for example, in the task model we can have tasks that depend on a certain modality (eg selecting a location in a graphical map or showing a video), and are neglected if they cannot be supported (eg in a platform having only the vocal modality).

For each target platform it is possible to focus just on relevant tasks and then derive the corresponding abstract description, which is in turn the input for deriving a more refined description in the specific concrete language available for each target platform. Since the concrete languages share a common core abstract vocabulary, this work is easier than working on a number of implementation modality-dependent languages. Our tool MARIAE is currently able to support the design and implementation of interactive service-based applications for various platforms: graphical desktop, graphical mobile, vocal, multimodal (vocal + graphical) and can be freely downloaded.

The tool has been developed in the ServFace project, whose goal was to create a model-driven service engineering methodology to build interactive service-based applications using UI annotations and service composition. The project began in 2008 and finished in 2010. The institutions involved were ISTI-CNR, SAP AG (Consortium Leader), Technische Universität Dresden, University of Manchester, W4.

Links:
ConcurTaskTrees Environment:
http://giove.isti.cnr.it/tools/CTTE/home
MARIAE Tool: http://giove.isti.cnr.it/tools/MARIAE/home
HIIS Laboratory: http://giove.isti.cnr.it/
ServFace EU Project: http://www.servface.eu/

Please contact:
Fabio Paternò
ISTI-CNR, Italy
Tel: +39 050 315 3066
E-mail: fabio.paterno@isti.cnr.it

Training Crisis Managers in Strategic Decision-Making

by Amedeo Cesta, Gabriella Cortellessa, Riccardo De Benedictis, and Keith Strickland

The goal of PANDORA is to apply state-of-the-art ICT technologies to build a learning environment for strategic crisis managers. We are currently refining a first version where training sessions are animated by reproducing realistic crisis events and fostering creative decision-making. Central to PANDORA is an original use of the timeline-based planning strategies used to diversify crisis scenarios by creating alternative training paths and to model trainees behavioral patterns for personalized training.

Crisis management in emergency situations helps significantly to avoid major losses and may prevent emergencies from becoming disasters. The success of crisis management depends heavily on the effectiveness of high-level strategic choices and the reasoning abilities of decision makers.

Three different levels of decision makers exist in current approaches to crisis management:
- operational level or bronze commanders, directly operating on crisis scenarios, whose actions and results are monitored and communicated to higher levels
- tactical level or silver commanders, responsible for translating high-level strategic decisions into actions and related resources allocations
- strategic level or gold commanders, who identify key issues and decide strategies to resolve the crisis.

The PANDORA project aims at creating an advanced training environment for crisis decision makers who operate in highly stressful situations. They must react effectively and coordinate interventions with different authorities to limit the dangerous effects of crises and to enable quick recoveries. Contrary to almost all the state-of-the-art training systems, aimed at the operational or tactical level, PANDORA targets decision-making at the strategic level, which presents interesting open challenges.

There are two main approaches to training: (a) tabletop exercises (group discussions guided by a simulated disaster); (b) real world simulation exercises (field-tests replicating emergency situations). Tabletop exercises are low cost and easy to organise, but they cannot recreate the real atmosphere, in terms of stress and pressure. On the other hand, real world simulations can be very effective but are extremely expensive and difficult to organize.

PANDORA aims at replicating the benefits of both training approaches by developing a system capable of guaranteeing the realism of the real world simulation and the practicality of tabletop exercises. A user-centered approach is followed and we have worked in close collaboration with the UK Emergency Planning College, which has identified the main

requirements, and is influencing the design and implementation decisions.

Figure 1 summarizes the main concept of PANDORA. A group of trainees, from different agencies (eg, Civil Defence, Health, Fire Service, Police, Transportation) access the training system. If some authorities are not present, they are simulated through Non Player Characters. Each trainee feeds personal data to the PANDORA kernel, which gathers this information to build a user model (Behavioral Module). On the basis of this model, the system synthesizes personalized training paths (Behavioral Planner). The output of this process is passed to a second module (Crisis Planner), which uses both the Behavioral Module indications and knowledge of the chosen scenario to plan sequences of stimuli appropriate for the group (information shared among all trainees)

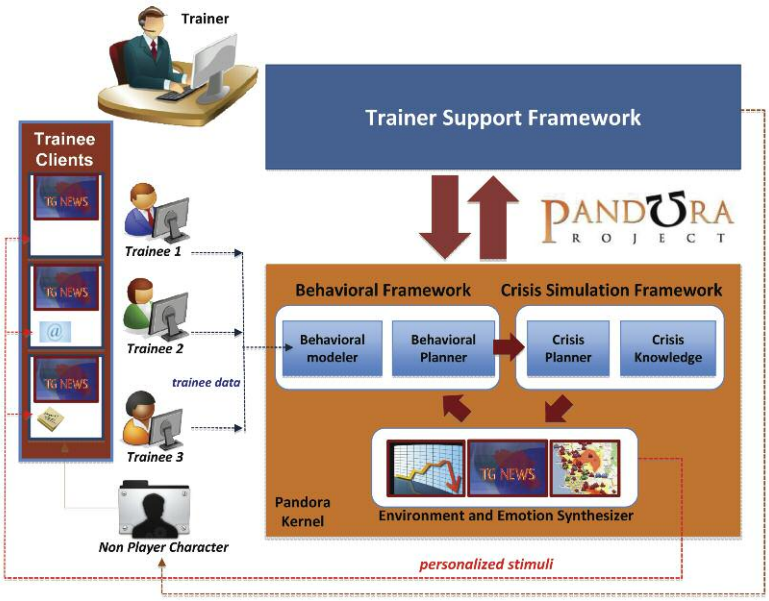


Figure 1: The PANDORA system architecture.

and the individual trainees (information tailored to induce the "right level of stress").

The plan is then passed to the Environment and Emotion Synthesizer, responsible for an effective rendering of the various stimuli. A separate module (Trainer Support Framework) allows trainers to control the training session and dynamically adjust the stimuli based on their experience.

PANDORA uses timeline-based planning technology which allows for rich domain modelling and uses both temporal and resource constraints. A timeline can be seen as a stepwise constant function of time. Specifically it is an ordered sequence of values holding on subsequent temporal intervals. This approach has been used both in the Behavioural and the Crisis Framework.

In the first case some psycho-physiological trainee features, shown to influence human behaviour under crisis, are modelled and updated during training as timelines. On the basis of this model, the Behavioural Planner synthesizes goals for the Crisis Planner. The Crisis Planner creates training storyboards, sets of "events" communicated to the trainees (eg, a news video from the crisis setting, a phone call or e-mail from an operational or tactical manager). Additionally, the Planner "reacts" to trainees' strategic decisions, triggering subequent events to continue the session.

The overall system empowers the trainer with a new means for training people. Indeed the suggested crisis stimuli and the behavioural analysis are presented to the trainer to influence at any moment the training session, in perfect line with a mixed-initiative style.

Links:
http://www.pandoraproject.eu/
http://epcollege.com/
http://pst.istc.cnr.it/

Please contact:
Amedeo Cesta, ISTC-CNR, Italy
E-mail: amedeo.cesta@istc.cnr.it

Keith Strickland – EPC, UK
keith.strickland@cabinet-office.x.gsi.gov.uk

Security and Resilience in Cognitive Radio Networks

by Vangelis Angelakis, Ioannis Askoxylakis, Scott Fowler, David Gundlegård, Apostolos Traganitis and Di Yuan

After more than a decade of research, system security and resilience is now the major technological barrier for the Cognitive Radio (CR) to be adopted by the telecommunication industry. New ideas are required to make CR networks secure and robust against attacks taking advantage the inherent characteristics of the CR functionality. This work explores key points that urgently need to be addressed.

Cognitive radio (CR) is a term with many possible meanings in the telecommunications literature of the past decade. Most commonly, a cognitive radio device is based on a software-defined radio (SDR), and has an adjustable front-end, which allows it to tune on different frequencies, power levels and modulation schemes. The SDR infrastructure has a programming interface that enables these configuration options. These, in conjunction with the context of operation (radio interference and noise, traffic demand, mobility levels, element status, location, etc) are made available to a decision-making entity, which selects the best configuration by solving an optimization problem with respect to some objective function. Further input is contained in a system knowledge base that codes the contexts encountered and maps them to specific radio configurations that can be used. This mapping can be done through a reasoning engine which is essentially a set of logical inferring rules (policies) and "reasons" (i.e. searches) for a proposed set of actions that will manipulate the current state of the knowledge base in an

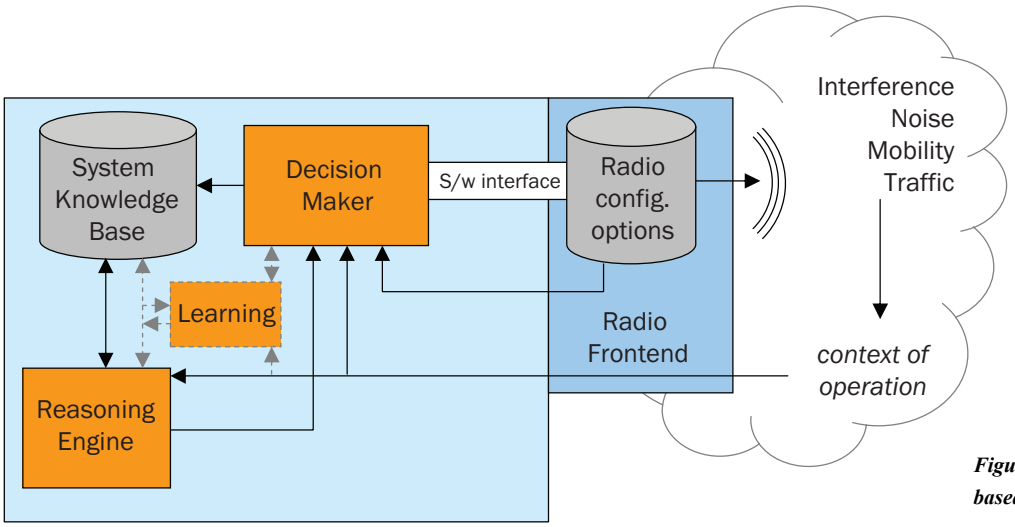


Figure 1: Components of a SDR-based Cognitive Radio.

optimal way. In principle, the CR functionality may also include a learning engine making it capable of starting with no policies, and by utilizing a variety of classic Artificial Intelligence (AI) learning algorithms identify which configuration will work optimally in the current and future contexts.

While CR devices are built with components that have been well-established in the telecommunications and computer science disciplines, the existing approaches to provide robustness and effective security for a network of CR devices are inadequate. Due to the particular characteristics of the CR systems, new types of attack are possible and some of the well-known types increase in complexity. Therefore, new ideas are needed to make CR networks secure and robust against specific attacks, especially against those that are inherent to the CR functionality.

Specifically, sample attacks can target the inputs considered for the formation of the CR networks and the respective optimization problem, for instance attacks might compromise the accuracy of the context information sensed or the set of candidate nodes that may be involved in the network. One of the key features of cognitive radio is that sensory manipulation can lead to knowledge manipulation, meaning that malicious actions in the present can affect the radio performance in the future. Other attacks can target the outputs describing the CR network that should be formed even under unharmed inputs, eg, a set of nodes that should be involved, configurations that should be selected, etc. Finally, as in all wireless networks, attacks can be designed to lead the client devices to configurations that are inefficient in terms of energy and make them run out of batteries.

There is, therefore, the need for comprehensive and energy efficient mechanisms to discourage, identify and mitigate the attacks at all phases of the cognitive cycle, in order to obtain CR systems that are trustworthy, efficient and dependable. Furthermore, in this scope there is need for a new systemic evaluation of the robustness of a CR system, in order to set the requirements and expectations for a resilient CR network from a security viewpoint.

The targets of this joint work are to initially identify the threats at the different layers and to classify the major topics, such as jamming, sensory manipulation, belief manipulation, routing, etc , for each layer.

Further on we aim to develop new mechanisms for detecting, isolating and expelling misbehaving insiders. Such malicious nodes may have all the credentials provided by an "off the shelf" security solution as the ones proposed to be applied in IEEE 802.22. This therefore requires the detection of abnormal secondary user operation through pattern analysis and node cooperation, since the feedback from the CR devices will enhance the efficiency required for such an Intrusion Detection System (IDS).

Improving sensory input can reduce the exploitability of cognitive radios in a cross-layer fashion. For example, if the CR could identify the difference between interference and noise, they would distinguish between natural and malicious RF events. Identification and quantification of potential gains from the interference identification is important in order to define more robust CR MAC policies. Furthermore, in a distributed environment, a network of cognitive radios can fuse sensor data to improve the quality of input for the cognitive engine. Such techniques should be designed with small information exchange requirements in order to be energy efficient, keeping in mind that the client CR devices will be battery operated.

This project is a joint effort by the Mobile Telecommunications group of the Department of Science and Technology in Linköping University and the Institute of Computer Science of the Foundation for Research and Technology-Hellas (FORTH-ICS).

Please contact:
Vangelis Angelakis,
Mobile Telecommunications, ITN-LiU, Sweden
Tel: +46 11 363005
E-mail: vangelis.angelakis@liu.se

Ioannis G. Askoxylakis,
FORTH-ICS, Greece
Tel: +30 2810 391723
E-mail: asko@ics.forth.gr

Smart Cameras for Cities of the Future: Simultaneous Counting of Pedestrians and Bikes

by Ahmed Nabil Belbachir, Norbert Brändle and Stephan Schraml

The Austrian Institute of Technology has developed a stereo vision system that monitors and counts pedestrians and cyclists in real-time. This vision system includes a processing unit with embedded intelligent software for scene analysis, object classification and counting.

Europe has one of the highest population densities in the world, mostly concentrated in urban areas. The human activities in the countries of the European Union produce about 14.7 % of the worlds' CO_2 emissions, ranking the European Union third highest emitter after USA and China. Road traffic is one of the principal contributors of CO_2 emissions mainly due to an aging car fleet on Europe's roads, growing congestion, increasingly dense traffic, a lack of traffic management, slow infrastructure improvement and a rise in vehicle mileage.CO_2 is not a toxic emission for the population like the pollutants (NO_x, PM_x, SO_2, CO) and it is therefore not regulated by the EC at the moment. However, CO_2 emissions contribute to climate change.

Current investigations on cities of the future aim, among others, to include concepts for the reduction of the number of cars on urban roads and implementation of widely available energy efficient public transportation. These investigations also deal with creating city designs that combine living, working, shopping and entertainment, and which are more pedestrian- and cyclist-friendly.

In other words, the mobility approaches of the future cities will concentrate on walking, biking and using available public transportation. Therefore, it is very important to act early in establishing new technologies, tools and approaches for monitoring and management of future urban traffic to maximize safety and security of citizens.

Within the framework of a national research activity, AIT has developed an event-based stereo vision system for real-time outdoor monitoring and counting of pedestrians and cyclists. This vision system comprises a pair of dynamic vision

Figure 1: Image of the event-based stereo vision system.

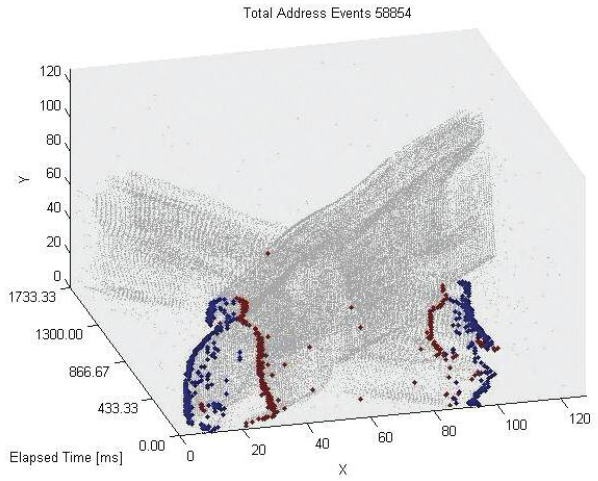


Figure 2: Raw data from the event-based detector spatiotemporally represented.

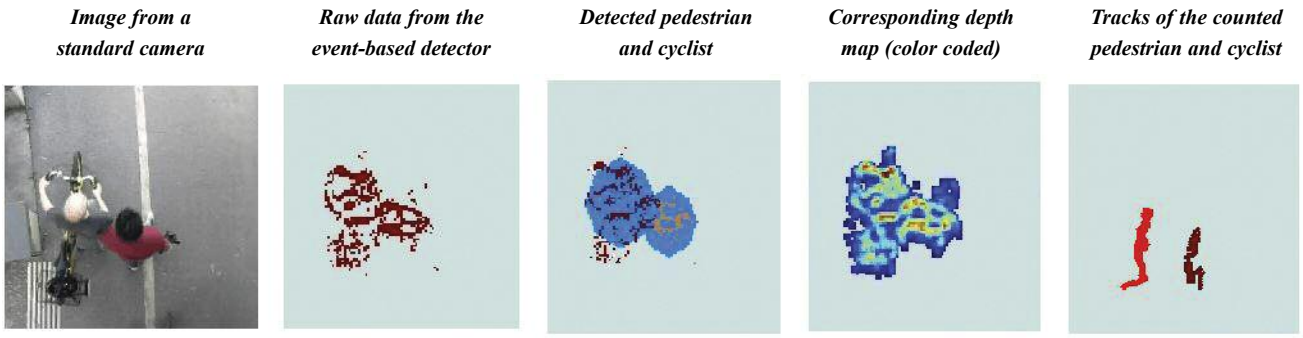


Figure 3: Illustration of process for detection and counting pedestrian.

detector chips, auxiliary electronics and a standalone processing unit embedding intelligent software for scene analysis, object classification and counting.

The detector chip consists of an array of 128x128 pixels built in a standard 0.35µm CMOS-technology. The detector aims to duplicate biological vision with an array including a set of autonomous self-spiking pixels reacting to relative light intensity changes by asynchronously generating events. Its advantages include high temporal resolution, extremely wide dynamic range and complete redundancy suppression due to included on-chip preprocessing. It exploits very efficient asynchronous, event-driven information encoding for capturing scene dynamics (eg moving objects).

The processing unit embeds algorithms for calculating the depth information of the generated events by stereo matching. It also embeds a spatiotemporal processing method for the robust analysis of visual data encompassing dynamic processes such as motion, variable shape, and appearance enabling real-time object (pedestrian or cyclist) classification and counting. The whole system has been evaluated in real (outdoor) surveillance scenarios as a compact remote standalone vision for pedestrians and cyclists.

Figure1 depicts the event-based stereo vision system including the pair of detector chips, the optics, the auxiliary electronics and the processor core module mounted on the backside of the board (not visible on the picture). The events generated by one detector chip are represented in Figure2 for two persons crossing the sensor field of view over a time period of 1.73 sec. The asynchronous nature of these events allows an ideal spatiotemporal representation and processing of the data. Figure3 shows the processing steps and results for counting pedestrians and cyclists. An image of the scene using a standard camera is shown on the left. Its corresponding data using one event-based sensor is rendered in an image-like representation (second- left). The middle images show the processing results of the detection and of the stereo matching. The right image depicts the tracking results, which allow the pedestrians (brown track) and cyclists (red track) to be counted.

Link:
http://www.ait.ac.at

Please contact:
Ahmed Nabil Belbachir, Norbert Brändle,
Stephan Schraml, Erwin Schoitsch
AIT Austrian Institute of Technology / AARIT, Austria
E- mail: nabil.belbachir@ait.ac.at,
norbert.braendle@ait.ac.at,
stephan.schraml@ait.ac.at,
erwin.schoitsch@ait.ac.at

Simulation of Urban Traffic including Bicycles

by Jelena Vasic and Heather J. Ruskin

The aim of this research is to contribute to the 'greening' of city traffic through investigation of heterogeneous traffic dynamics on urban road networks.

This study, which builds on previous work in the area of traffic flow modelling done by our group, is one of several current related projects in the Centre for Scientific Computing & Complex Systems Modelling at Dublin City University. The work is funded by the Irish Research Council for Science, Engineering and Technology (IRCSET), through an 'Embark Initiative' postgraduate scholarship.

The motivation behind the project lies in a desire to contribute to the 'greening' of urban transport. Its focus, in concrete terms, is on dynamics of bicycle traffic as part of the overall urban transport picture in cities like Dublin. The city, with respect to bicycles, is characterised by a lack of dedicated cycle lanes and bicycle-specific control measures, that is, by motorised and non-motorised modal coexistence under conditions suited to exclusively motorised flows. Understanding these dynamics is crucial to providing the best control and management strategies, in terms of successfully promoting 'green' modalities at the lowest possible cost.

Discrete simulation models of traffic based on cellular automata (CA) have existed since the 1980s but have only become a widely researched topic since the availability of computers sufficiently powerful to tackle the complexities of vehicular traffic. These models are microscopic in nature, in that they describe the behaviour of individual particles and their interactions at a local level, but have the purpose of ultimately providing information about throughput and average delays. Complexity is added to the task of modelling traffic flows by the presence of many transport modes, in particular those for which the units differ widely in size, potential for movement and behaviour. Network structure is another fun-

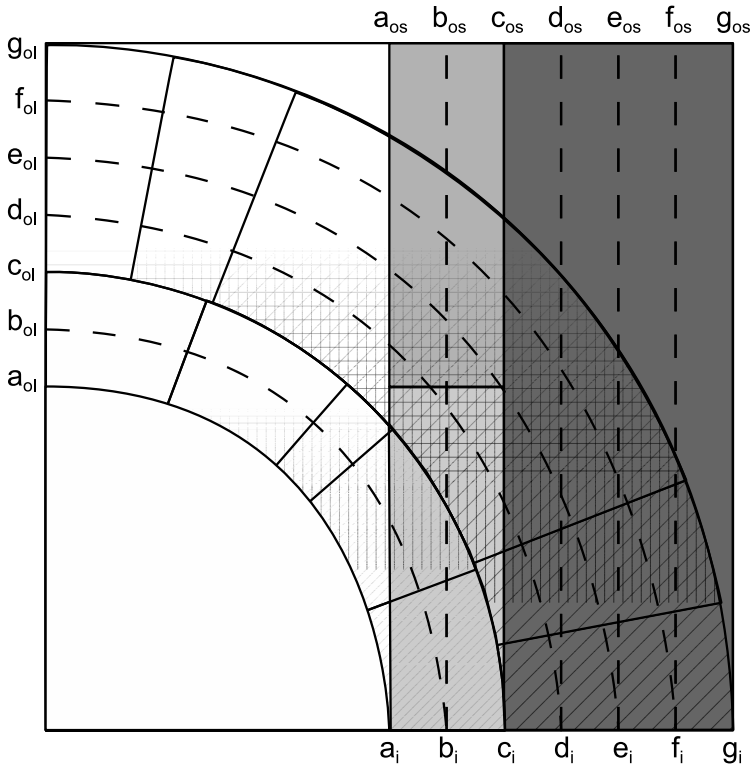


Figure 1: Discretisation of the natural geometry of a left turn (on a left-hand driving road, as in Ireland or the UK): The transversal positions are defined by lines $a_i a_{os}$ ... $g_i g_{os}$ for straight ahead and by lines $a_i a_{ol}$ ... $g_i g_{ol}$ for turning left. Cells of both the left-most bicycle position and the right-most car position, in the straight ahead direction and the left direction, are shown by shadings and hatchings, respectively. At the entry point, both cars and bicycles are faced with a decision (left or straight ahead?). A conflict exists between bicycles in the left-most position going straight and cars in the right-most position going left.

damentally complex element in a traffic system under simulation.

In the first phase of this project, our aim was to define a simulation model that would answer three questions:

- How can we incorporate two modalities, cars and bicycles, with their differing characteristics, into a shared geometric space (representing a street without a dedicated cycle lane)?
- How do we generalise the representation of complex infrastructural features of the network, such as intersections, for the multi-modal case?
- How do we define a general behaviour model for vehicles on a random network of roads?

We have, to date, answered these questions through a simulation model, which provides macroscopic measurements for random network configurations. (1) In addition to the discrete movements in the longitudinal dimension of the road, we have introduced a discrete measurement of the transversal position of vehicles, necessary in the conditions of lane-sharing, since a vehicle's transversal position is not only defined by the lane it occupies but also by its take up of the lane space. This means that allowed positions overlap. Our model is thus strictly not a CA one, although it still retains CA elements, in its basic movement rules. (2) Since the presence of more than one geometrically different model makes the abstraction of intersections and other complex features of the network extremely difficult, the approach has been to draw a geometrically natural representation of an intersection to be modelled, including conflicts and divergence of roads, and to extract a numerical model of the intersection literally "from the picture". In order to make this model fit with the shared road model, transversal positions on routes through an intersection are mappable onto transversal positions of a shared road. (3) From the point of view of vehicle movement, a network can be reduced to a collection of "conflicts" and "decisions". A conflict point is a place where two routes overlap, while a decision point is a point in the network where intelligence needs to be applied for the next movement to be determined.

Further work on this project will initially involve the application of the model to more complex network configurations. As the scale of the simulations is increased, additional processing power will be needed and we aim at devising parallelization strategies for the simulations. Once the robustness of the model is confirmed through simulations of the highly complex network configurations, different management and control strategies will be modelled and compared. Real life measures taken in the direction of bicycle-friendliness will be of particular interest, as simulations of "before and after" scenarios, incorporating available data on the effects of changes, will provide a true test for the model.

Links:
http://sci-sym.computing.dcu.ie
http://computing.dcu.ie

Please contact:
Jelena Vasic
Dublin City University, Ireland
Tel: +353 17006747
E-mail: jelena.vasic@computing.dcu.ie

Simulation and Assessment of Vehicle Control Network Systems

by Alexander Hanzlik and Erwin Kristen

The conventional automotive industry is a market of mass production. On the one hand, due to the fact that the same platform may be used for different car generations, the lifecycle of a control network architecture (physical network and communication schedule) is expected to be at least one decade. On the other hand, future extensions to car functionality come along with increased bandwidth requirements. Additionally, there are safety requirements to fulfill that have to be reflected in the design of the control architecture. The technical challenge is the design of an architecture that fulfills existing requirements while being open for new functionalities without the necessity to re-design the whole control network.

This challenge is addressed by the DTF Data time flow simulator, a discrete-event simulation environment that will help to identify and validate an optimal car control architecture with regard to technical requirements, safety requirements and industrial norms. The idea is to derive the control architecture in an early design phase, ideally at the requirement specification stage, to build a simulation model of the architecture and to test the control network in the simulation environment. If the tests reveal requirement violations (eg deadlines of safety-relevant signals are missed), the control network is re-designed in the DTF simulation environment or the communication schedule is modified. This cycle is repeated until all requirements are met.

Figure 2 shows the structure of the DTF simulation environment. Starting with a graphical description of the system, the converter generates a textual bus model description that in turn is the input for the parser. The parser checks the bus model description for correctness and consistency and passes the model description to the DTF simulator engine.

The simulator engine creates the necessary elements according to the model description. Then, the event list is generated according to the drive cycle description (an example for a drive cycle description is a sequence of events that defines different accelerator pedal positions for different points in time). Last, the event list processing is started with the first event. In the course of the simulation process, an event received at an element may lead to the creation of another event that is added to the event list. Simulation is complete when the event list is empty. All events are logged into a simulation results file that can be processed offline after simulation ends to gain data necessary for visualizations and for further analysis.

Principle of operation

The DTF principle of operation is to build up complex control systems from primitive building blocks (eg sensors, processors, actuators), the elements. Each element has an input buffer, a propagation delay and an action routine. Upon reception of a trigger, an element reads its input buffer, generates an output value according to its action routine, and transmits the output value with a defined propagation delay. Element triggers are event triggers (an event for this element is defined in the event list) or time triggers (the element triggers itself with a defined period). Each element has one or more inputs and one output. Elements can be grouped into super-elements, derived blocks with a high inner complexity which group logical functions belonging together into a single block (eg a Controller Area Network CAN bus). Signals are issued to the sensor elements and signal propagation is observed, both in the domains of value and time, from the sensors over the control network to the actuators. From the signal propagation time distribution over the control network important information can be gained about the

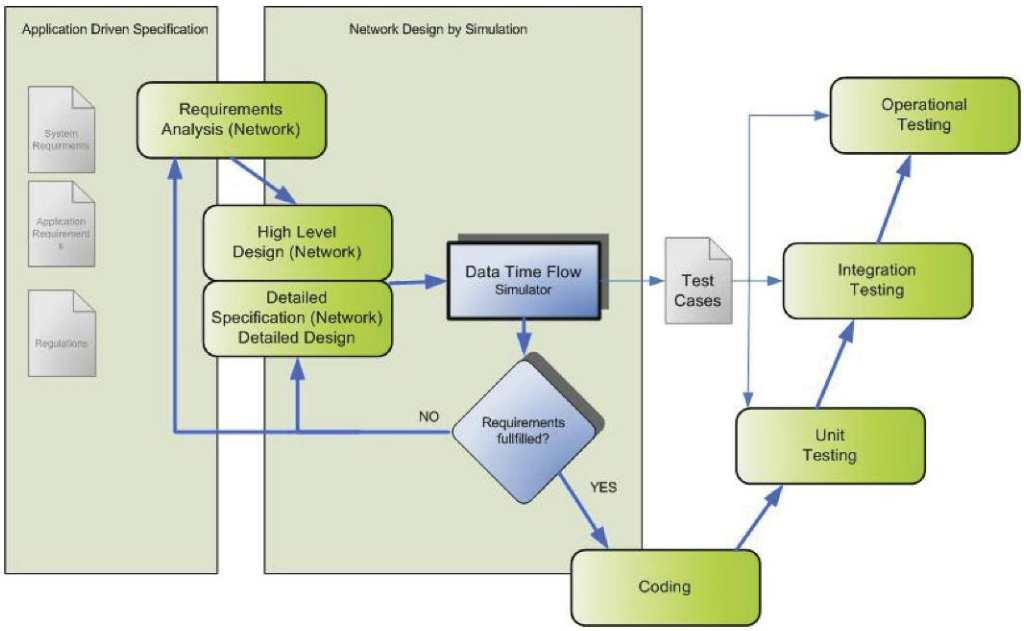


Figure 1: DTF development cycle.

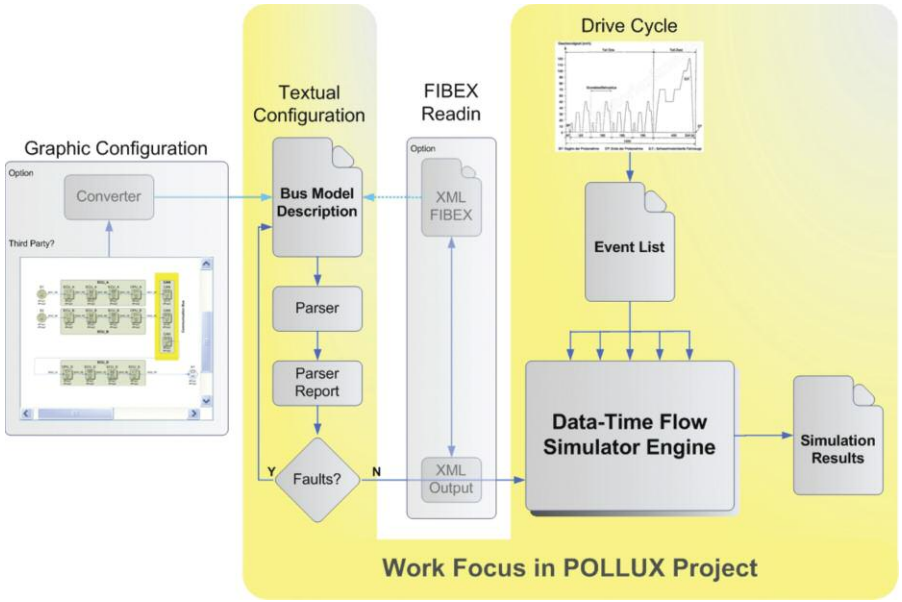


Figure 2: DTF simulation environment.

dynamics and responsiveness of the system, especially for safety-relevant signals like the accelerator pedal position that are usually subjected to real-time constraints.

Validation

For validation of the DTF implementation a Concept Development Platform CDP is used to compare simulation results and bus measurements from the CDP. As shown in Figure 3, the CDP is a single-axe driving platform where each wheel is driven by one electric motor, stabilized by a free-running support wheel at the back. The CDP provides the mechanical system to develop automatic control software for the powertrain as well as the necessary structures for network design. The Data Time Flow Simulator DTF is currently under development at the Austrian Institute of Technology (AIT) in the context of the ARTEMIS Joint Undertaken (JU) POLLUX project that is related to the control electronics architecture design of the next generation of electric cars.

First simulation results are available and have been presented at the annual POLLUX project meeting in Brussels. The DTF simulator results were approved by the project partners and this tool is going to play an important role in simulation and assessment of vehicle control network systems.

Please contact:
Erwin Kristen
AIT Austrian Institute of Technology GmbH / AARIT, Austria
E-mail: erwin.kristen@ait.ac.at

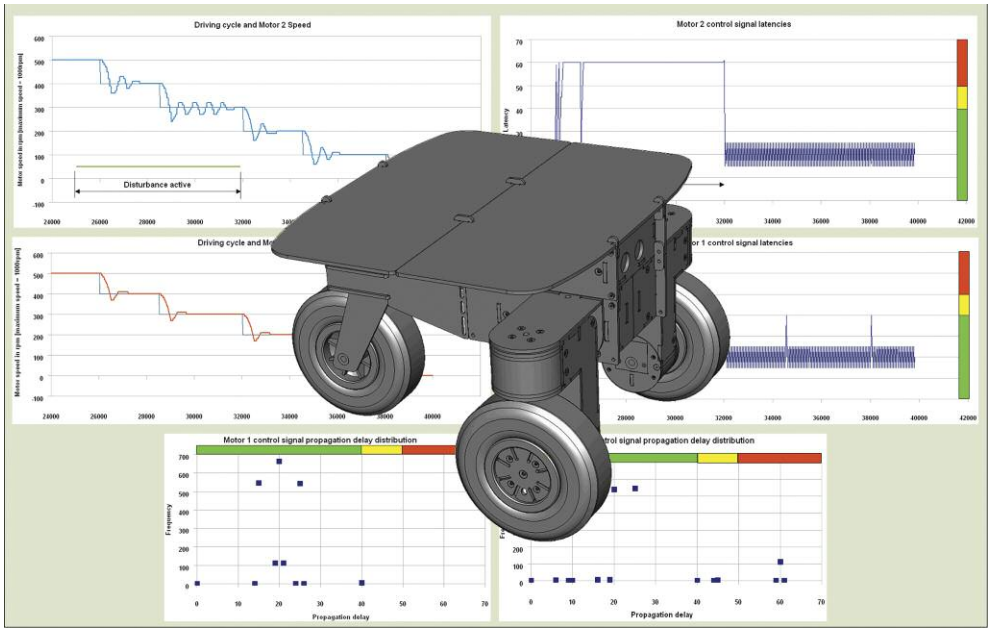


Figure 3: Concept Development Platform and DTF Simulation Results.

Filling the Gap between ICT and HydroMeteo Research Communities: the DRIHMS Project

by Alfonso Quarati, Nicola Rebora, Michael Schiffers

Hydrometeorological science has made strong progress over the last decade as new modelling tools, post processing methodologies and observational data have become available. The goal of the DRIHMS project is to promote collaboration between the hydrometeorological and the GRID research communities in order to further advance the state-of-the-art.

The DRIHMS (Distributed Research Infrastructure for Hydro-Meteorology Study) project is an EU support action on the use of Grid, High Performance Computing (HPC) and Information and Communication Technologies (ICT) in the field of HydroMeteo Research (HMR). Its goals are:

- to promote the GRID paradigm within the European hydrometeorological research community
- to boost European research excellence and competitiveness in hydrometeorological and Grid research by bridging the gaps between these two communities.

DRIHMS is conducted by a consortium of hydrometeorology (DLR and CIMA) and ICT (LMU and IMATI) research centres that integrate complementary multidisciplinary know-how enabling the use of Grid-related technologies in the area of hydrometeorological science.

The prediction of floods and other hydrometeorological events relies on hydrological and meteorological forecast models that describe the hydrological cycle in the atmosphere. These predictions are based on observational measurements, for example of rainfall and river flow. In recent years, the quantity and complexity of the tools and data sets have increased dramatically for three reasons:

- the increasing availability of remote sensing observations from satellites and ground-based radars that provide complete three-dimensional coverage of the atmospheric and land surface state
- the development of forecasting methods that combine multiple numerical weather prediction and hydrological models through stochastic downscaling techniques to quantify the uncertainty in the forecast, multiplying the computational costs

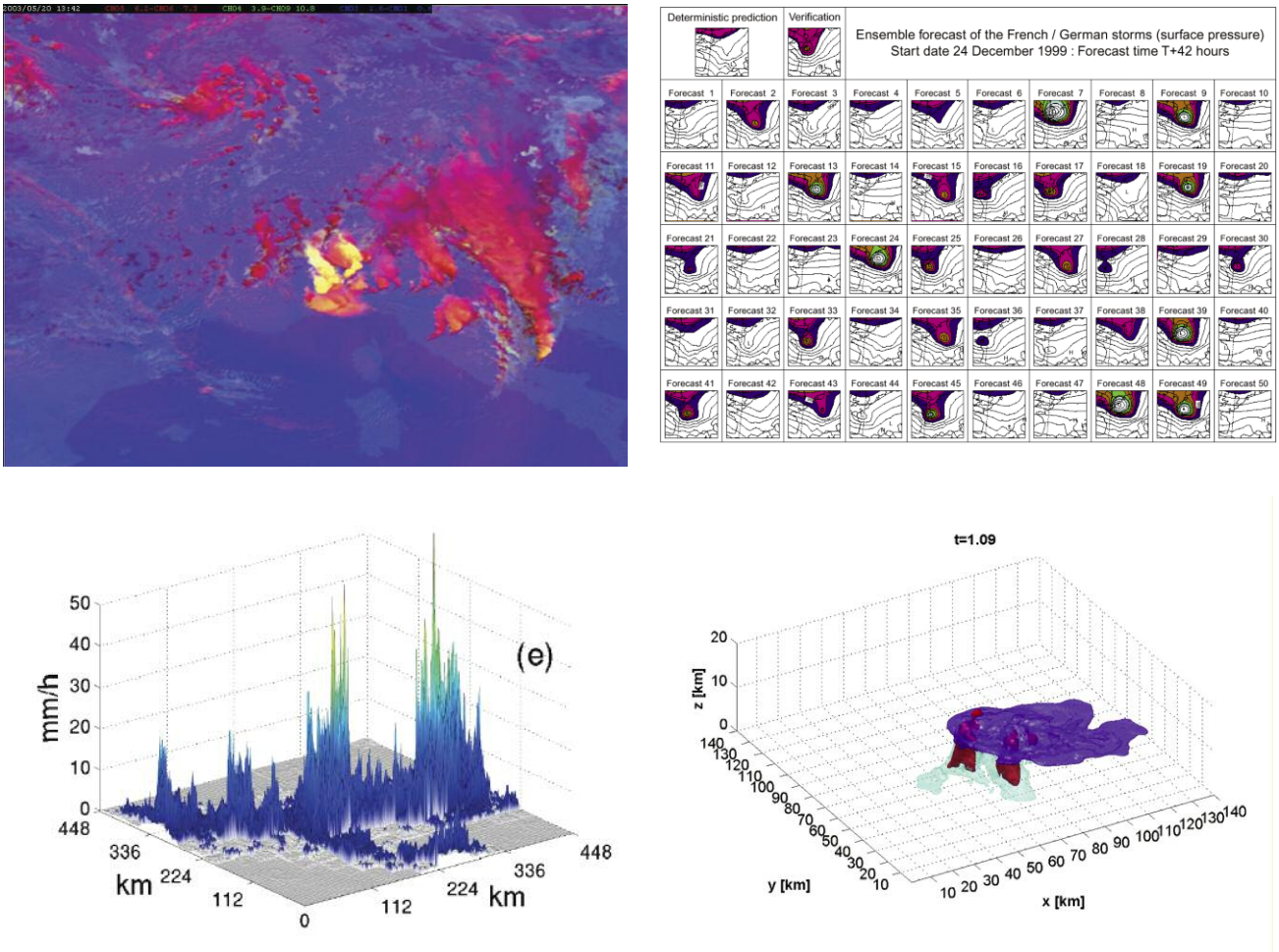


Figure 1: The HMR forecasting chain: satellite data (top left), meteorological ensemble probabilistic system (top right), stochastic downscaling (bottom left) and high-resolution meteorological modelling (bottom right).

- increasing recognition of the need to understand the entire forecasting chain, from observations through to civil defence response, resulting in complex workflows able to combine different data sets, models and expertise in a flexible manner.

HydroMeteo Research is closely linked to operational forecasting. Researchers rely on data archives maintained by operational agencies and increasingly make use of operational modelling tools. However these data sets and tools are mainly the property of national agencies and are not often easily obtainable at a European level. A second major source of material for research is the existence of ad hoc collections of data from field campaigns and experimental instruments. However, the heterogeneity of the data, and of the metadata describing it, makes it difficult for scientists to locate and exploit the data relevant for their task.

Similarly, the scattering of hydrometeorological data tools among national and ad hoc collections is a substantial barrier to progress in research. On the one hand, weather systems freely cross national boundaries, rendering national archives of limited use. This has long been recognised in meteorology, and indeed the World Meteorological Organisation (WMO) effectively coordinates the international exchange of much meteorological data. Unfortunately this does not include much of the high resolution data required for hydrometeorological research. Figure 1 shows the key elements in an HMR forecasting chain; they are all highly demanding from the data storage and high performance computing standpoints.

Similarly, the scattering of hydrometeorological data tools among national and ad hoc collections is a substantial barrier to research progress. On the one hand, weather systems freely cross national boundaries, rendering national archives of limited use. This has long been recognised in meteorology, and indeed the World Meteorological Organisation (WMO) effectively coordinates the international exchange of much meteorological data. Unfortunately this does not include much of the high resolution data required for hydrometeorological research.

The need for large data sets and complex numerical models is not unique to hydrometeorological research. Under the name of e-science, a number of initiatives have been undertaken to provide the necessary ICT infrastructure, including EGEE (Enabling Grids for E-sciencE), SEE-GRID-SCI (South East Europe -GRID e-Infrastructure for regional e-Science), and the German C3-Grid.

DRIHMS aims at identifying the key areas for hydrometeorological research which require a network-based and distributed approach in terms of data and software sharing. Project activities focus on discussing, defining and communicating the requirements for the porting and deployment of state-of-the-art research applications and tools over heterogeneous Grid middleware.

The key element of DRIHMS is the organization of a set of networking activities (including web based questionnaires, invitation-only workshops and open conferences), involving both hydrometeorologists and Grid experts, aimed at overcoming current limitations in the sharing of tools and knowhow in the European HMR community. The networking activities will facilitate the development of a pool of common knowledge from the knowledge currently available and hopefully derive new knowledge from last generation hydrometeorological processes observing/modelling systems.

DRIHMS is currently surveying the ICT and HMR communities in order to collect the requirements of the HydroMeteo research community and to assess which ICT tools can satisfy them. So far almost 300 questionnaires have been completed by scientists from all over the world, but we would like to request the assistance of all those interested in this initiative to spare a few minutes to complete the questionnaires online at the link below.

Link:
http://www.drihms.eu/survey

Please contact:
Alfonso Quarati, IMATI-CNR, Italy
E-mail: quarati@ge.imati.cnr.it

The SOCIETIES Project: Combining Pervasive Computing with Social Networks

by Kevin Doolin, Pierfranco Ferronato and Stefania Marrara

SOCIETIES will design and deliver a complete integrated package for the creation and management of Social Networks. The project will extend pervasive systems beyond the individual to dynamic communities of users.

Four out of ten of Alexa Top 500 Global sites (http://www.alexa.com/topsites as of November 2010) are Social Network sites. Barack Obama based his successful presidential campaign on social media and used them to obtain funding. LinkedIn, a Social Network of professional profiles, has seen its traffic doubling during the economical crisis. Although there is no doubt that Social Networks have altered the expectations of Internet users they are still mostly based on certain assumptions that limit their capabilities and prevent them from exploiting their full potential.

The first assumption is that the information stream that feeds a Social Network is provided interactively, through a Web browser, by the human members of the Network. This assumption has recently been partially invalidated with the adoption of contextual data sources for Social Networks (eg, Facebook Places and Facebook Deals).

The second assumption is that the mesh of relationships of a Social Network user is a "flat" network. In other terms, there is no way of defining hierarchies of networks where each

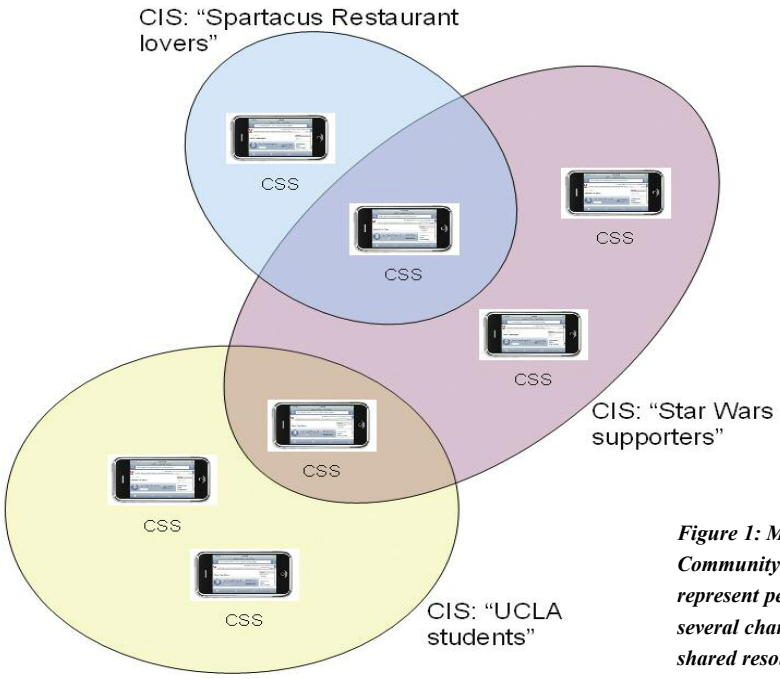


Figure 1: Mobile CSSs participate in one or more Community Interaction Spaces (CIS) which represent pervasive communities. Each CIS offers several characteristics to its CSSs such as a set of shared resources or services.

node in a network at a given level is actually a network itself at a lower level in the hierarchy.

To overcome these limitations SOCIETIES, an Integrated Project of the EC Seventh Framework Programme, will investigate how pervasive data sources can increase the usefulness and accuracy of social networks. SOCIETIES will improve the utility of Future Internet services, merging social computing and pervasive computing, by focusing on four main objectives, which will represent the core for the definition of Cooperating Smart Spaces (CSSs).

CSSs are the building blocks for enabling pervasive computing in social communities, as they constitute the bridge between a user's context (devices, sensors etc.) and the user's social community. A CIS (Cooperating Interaction Space) is a collection of CSSs and/or supporting infrastructure services, that intends to collaborate for mutual agreed purposes.

The four main objectives of SOCIETIES are:

- to facilitate communities creation, organisation, management and communication via Community Smart Spaces, where pervasive computing is integrated with social computing communities.
- to provide an enhanced user experience – both for individuals and entire user communities – based on proactive smart space behaviour and dynamic sharing of community resources across geographic boundaries.
- to design and prototype a robust open and scalable system for self-orchestrating Community Smart Spaces.
- to evaluate, via three user trials, the usefulness and acceptance of the CSS software developed.

The main features that will be offered by a CSS to its user are the following:

- support the manual or automatic creation of static or dynamic communities. The creator of a community will be able to advertise it, or to invite particular users to join, and to specify principles governing the community itself. The system will be able to discover potential new members, also via social network site queries, as well as detecting and removing community members whose ties have become obsolete.
- enable users to share resources with other community members in a seamless unobtrusive manner.
- support multiple techniques for the discovery of relationships and behaviours within communities.
- allow for the orchestration of multiple communities to which its owner belongs, maintaining a registry of super- and sub- communities in community hierarchies along with policies on information disclosure and service access to members of other related communities.
- enable the proactive exchange of information on the situation, interests and resources of community members.
- provide intelligent conflict resolution among the members of a community based on mediation and negotiation.
- support ad-hoc communication at both intra- and inter-community levels, exploiting peer to peer communication techniques and wireless networking technologies.

The SOCIETIES consortium is coordinated by the Waterford Institute of Technology (Ireland), and includes the Heriot-Watt University (United Kingdom), Soluta.Net (Italy), the Deutsches Zentrum fuer Luft – und Raumfahrt Ev (Germany), the Zavod za Varnostne Tehnologie Informacijske Druzbe in Elektronsko Poslovanje (Slovenia), the Institute of Communication and Computer Systems (Greece), Lake Communications Ltd (United Kingdom), Portugal Telecom Inovacao Sa (Portugal), IBM Israel – Science and Technology Ltd (Israel), Institut Telecom (France), AMITEC Ltd (Greece), Telecom Italia s.p.a. (Italy), Trialog (France), Stiftelsen Sintef (Norway), and NEC Europe Ltd (United Kingdom). The project started on October 2010 and will end in March 2013.

Link:
http://www.ict-societies.eu

Please contact:
Stefania Marrara
SOLUTA NET, Italy
E-mail: smarrara@soluta.net

From left: Michel Cosnard, Wolfgang Wahlster, Felix Sasaki, Jeff Jaffe and Andreas Goerdeler.

German-Austrian W3C Office at DFKI

The World Wide Web Consortium (W3C) has opened its German-Austrian office at a new location: DFKI, the German Research Centre for Artificial Intelligence. This collaboration was celebrated on February 10th with an event in Berlin. Speakers from W3C, industry and DFKI as well as German ministries gave presentations and made the event a highlight for European politics, industry and research.

The internationally renowned DFKI, with facilities in Kaiserslautern, Saarbrücken, Bremen, and a project office in Berlin was founded in 1988 as a non-profit organization by several German IT companies and two research facilities. DFKI has been an active member of W3C for a long time and has contributed to areas like Semantic Web, EMMA, EmotionML, MathML or multimedia semantics. These achievements are one of several reasons to bring the German-Austrian W3C office to DFKI. In his opening presentation, Wolfgang Wahlster (CEO of DFKI) emphasized the central role that the Web plays for any kind of IT intensive industry. DFKI owns an ideal position in Germany to integrate W3C with research, politics and industry.

Participation in standardization efforts is a key means for DFKI to connect research with innovation and with the development of applications and products. In their presentations, Wolfgang Wahlster, Philipp Slusallek and Hans Uszkoreit gave an overview of the variety of W3C related topics in which DFKI is engaged: Object Memory Modelling (OMM), the Unified Service Description Language (UDSL), XML3D, and language technologies. Orestiz Terzidis (SAP) expressed his hope that USDL will soon be entering the regular W3C standardization process.

Andreas Goerdeler from the German Federal Ministry of Economics and Technology gave examples of BWMI funded projects that have created input to standardization within W3C. He also emphasized the importance of close cooperation between standardization bodies like W3C or ISO and its national counterparts.

Jeff Jaffe, CEO of W3C, gave a concrete and important example how that cooperation is brought to life. Last November, W3C received the status of an "ISO/IEC JTC 1 PAS Submitter". This means that W3C Recommendations can easily enter the ISO process and become ISO specifications. Jeff Jaffe and Philipp Hoschka, W3C Ubiquitous Web domain lead, presented a great variety of current topics in Web related standardization. These topics impressively demonstrated the demands from IT intensive industry. The presentation by Stefan Wess, CEO of the German company Attensity, illustrated the role of the Web in social media analysis.

The official part of the event ended with a contribution from Michel Cosnard, President of ERCIM and INRIA. Together with Wolfgang Wahlster, Michel Cosnard emphasized the central role that Web technologies and their standardization plays for European ICT infrastructure. To this end, ICT labs (a "Knowledge and Innovation Community" supported by the European Institute of Innovation & Technology) are an important means to connect IT related education, research and innovation.

The big variety of presentations and participants in the opening event of the German-Austrian W3C office at DFKI demonstrate that the office fulfils its role of bringing heterogeneous communities like politics, research and industry together. The office will help to build steady bridges between these communities and will help to fulfil their common goal, ie to work on the future of the Web.

More information:
http://www.w3c.de/
http://www.w3.org/Consortium/Offices

Euro-India cooperation in Future Internet Research Experiments

by Sathya Rao

The FP7 funded MyFIRE project organised the first Future Internet Research Experiments (FIRE) workshop in Pune, India on 16 December 2010 together with itsIndian partners. The workshop was co-located with the 'Beyond Internet' conference. The aim was to identify common interests in developing collaborative European-Indian experimental research platforms to study the Internet of the future.

MyFIRE has plans to organize international workshops related to FIRE in BRIC countries during its lifetime to extend the future Internet Research experiments to the international levels, involving research testbeds and research institutes from emerging economies. As a first of this series of workshops, the project organized a workshop on 16 Dec. 2010, in India at the industrial city of PUNE (near Bombay) which hosts the research centre for national grid and cloud computing. The other reason for

choosing Pune, was to develop closer links to international delegates participating in ITU Kaleidoscope event to address the 'Beyond the Internet' challenge, which was also organized in the same location on 13-16 Dec. 2010.

The agenda and the presentations of the workshop can be seen at www.myfire.eu/indian-workshop. The workshop was organized by ERNET India, which represents the national education and research network, representing 1300 Universities and research institutes. The workshop had 136 participants in total, representing different stakeholders in future Internet research. Mr. N. Mohan Ram, Director General of ERNET India welcomed the MyFIRE project partners, delegates and other guests to the workshop and presented ERNET India activities including network services, international connectivity and research collaborations.

The main theme of the workshop was 'Euro-India Future Internet Research and Experiments Collaboration' to assemble the experts from both India and Europe addressing the research experiments and the different aspects of future Internet design. In this context, the chief keynote speakers were invited from the Indian communication ministry to present the landscape of Indian Internet research, networks and testbeds deployed and planned (Mr. B. K. Murthy, Head, NKN & Internet Governance / E-Infra Divisions, DIT, India) and Prof. Ashok Jhunjhunwala, the eminent scientist, recipient of multiple national awards, Indian Institute of Technology, Madras, India, as well as Prof. Ramjee Prasad, Chairman (GISFI)) and the speakers from Indian Institute of Science, Indian Institute of technology, Center for development of advanced computing, and Department of Telecommunication, Indian Government and national contact point ECIR representatives. The workshop had two panels to address: 'Testing Environment for Development of Future Internet: Activities Landscape' and 'Future Internet Experiments: Opportunities for Cooperation Between Europe and India' so as to have interactive discussions. Testbeds and research experiments related to IPv6, QoS, sensor networks, mobility, interoperability and Planetlab were part of speakers' presentations.

From the Indian side, Prof. Ashok Jhunjunwala delivered the keynote address and discussed the importance of inclusive and sustainable innovation for the Future Internet. He also shared his vision of ICT innovation for the rural India. Dr. B.K.Murthy from Department of Information Technology (DIT) spoke about Indian ICT landscapes and road maps and provided details on DIT initiatives and presented the National Knowledge Network project initiated by the Government of India, which could be a model for many developed countries as well as for developing knowledge for society in the future.

The panel discussion in the morning session was chaired by Prof. Vinod sharma, Chairman, Department of Electrical and Communications Engineering, Indian Institute of Science, Bangalore, to discuss a testing environment for development of the future Internet. The panel members were Dr.Malati Hegde(IISc, Bangalore), Mr. Badri Narayanan Parthasarathy (TATA) and Dr. Paventhan.A (ERNET India). Dr. Malati Hegde spoke on 6PANview- a network monitoring system for their 6LOWPAN network testbed. Mr. Badri Narayanan Parthasarathy gave a talk "Beyond the Internet – Innovation for Future Internet Services" and provided details about IPv6 features and business benefits. Dr. A. Paventhan presented a talk on research test beds for Mobile IPv6 in Heterogeneous access networks and media-independent handover services. Prof. Abhay Karandikar (IIT, Bombay) presented "Next Generation Mobile Broadband: Challenges and Opportunities" and provided details on India's present telecom scenario, backhaul innovations and a low-cost, IP-based distributed architecture.

Opening session with key note speech from Prof. Ashok Jhunjunwala.

The afternoon panel discussion was chaired by Prof. Ramjee Prasad to discuss the topic, Future Internet Experiments: Opportunities for Cooperation between Europe and India. The panel members were Mr.Jørgen Friis (ETSI), Viswanath Talasila (Honeywell), Sathya Rao (Telscom/ETSI) and Prof.Abhay Karandikar (IITB). The panel had a lively discussion answering questions on collaboration opportunities.

MyFIRE provided the overview of FIRE activities in Europe and the survey results of MyFIRE findings. Over 135 participants were offered a comprehensive view of the FIRE initiative priorities, projects, and programmes in the European Union while benchmarking the Indian ICT research activities and initiatives, identifying the requirements of the research experiment landscape from providers' and users' perspectives and offering a vision of the way ahead in this collaborative endeavour.

The discussions both during the workshop and in private showed considerable interest of Indian researchers in European FIRE activities and in closer collaboration with possible participation in the future projects. The list of interested persons is available for the researchers in Europe on request, for developing future collaboration with Indian partners.

The questionnaire was distributed to collect the participants' feedback and the results were overwhelmingly positive: the Indian Scientific community would look forward to closer collaboration with European researchers, and they would like to have more such events to develop closer networking and cooperation.

The MyFIRE project is organising the next workshop on 8th of April 2011, in Beijiing, China. Details of the workshop can be seen at http://www.myfire.eu/chinese-workshop.

Link: http://www.my-fire.eu

Please contact:
Sathya Rao, Telscom, Switzerland
E-mail: rao@Telscom.ch

DL.org Workshop on Digital Libraries, Open Access and Interoperability Strategies

by Stephanie Parker
and Giuseppina Vullo

DL.org, an EC-funded Coordination Action on Digital Library Interoperability, Best Practices and Modelling Foundations, has adopted a comprehensive and innovative approach to top-level challenges in the field by harnessing the global expertise that exists through dedicated groups.

Digital Libraries should enable access to knowledge in multi-modal format to any citizen, anywhere, anytime, breaking down the barriers of distance, language and culture. Building and maintaining scientific e-Infrastructures, preserving cultural heritage, and supporting educational processes are just some examples of the value-add of Digital Libraries, which are by definition complex systems, intrinsically interdisciplinary and heterogeneous. Interoperability is a key-step to ensuring that digital libraries continue to grow in a way that allows users to navigate through different sources within an integrated single environment. It is also a multi-layered, context-specific concept which can be analyzed from organizational, semantic, and technical levels. The role of repositories and Open Access has been crucial to broaden the function of Digital Libraries within the research community. Open Access Repositories (OARs) have also enhanced the reputation of institutions by making their research more visible and bringing greater return on investment for funding agencies.

To weave together these topics central to advancing a collective mission that cuts across disciplines, professional roles and geographical boundaries, DL.org hosted a workshop on 4 February 2011 at the British Academy in London. The Workshop shone the spotlight on existing frameworks and best practices key to achieving open, interoperable information systems by triggering a multi-disciplinary debate. Discussions proposed common strategies for interoperability and how to implement mechanisms for exchanging, sharing and integrating results between Digital Libraries and Open Access Repository communities.

Leonardo Candela (ISTI-CNR. Italy), Vittore Casarosa (ISTI-CNR, Italy), and Giuseppina Vullo (HATII, at the University of Glasgow, UK) showcased key DL.org outputs produced for the Library and Information Science community. The DL.org Digital Library Reference Model, stemming from the DELOS Network of Excellence, has been enhanced and expanded to reflect the investigations of international experts on content, functionality, user, policy, quality and architecture. A dedicated Checklist enables designers and assessors of a digital library to determine conformity with the Reference Model. The Cookbook, with a comprehensive and pragmatic approach, provides a portfolio of best practices and pattern solutions to face common challenges when it comes to developing large-scale interoperable Digital Library systems.

Hans Pfeiffenberger (Alfred Wegener Institute, Germany) underscored the need to ensure long-term preservation of scientific knowledge with policy embedded in data repositories to create digital data libraries with persistent accessibility. DataCite, a Digital Object Identifier (DOI) registration agency for research data, is now considering to ask data repositories for some kind of certification, while also fostering global interoperability about a specific policy issue. Heather Joseph (SPARC, US), director of the Scholarly Publishing & Academic Resources Coalition, brought new policy insights from the U.S. Open Access serves as a compass point to ensure more open and equitable system of scholarly communication, leveraging digital networked technology and ultimately reducing the financial pressure on libraries through a holistic approach. Clear trends are emerging at higher policy level for Open Access to achieve the interoperability promised by Open Access by making it "the default".

The talk by Pablo De Castro (University of Carlos III Madrid, Spain) from the SONEX (Scholarly Output Notification & Exchange) Workgroup focused on deposit-related interoperability and the analysis of use cases by teaming up with initiatives already working on technical solutions. One of the impediments to collaboration between the Current Research Information Systems (CRIS) and Open Access Repositories (OAR) in the UK stems from different approaches to metadata publishing with data fragmented across different services. Peter Burnhill (EDINA, UK) advanced the idea of interoperability between repositories and of repositories with the wider web. However, important questions include determining whether such an approach should be chiefly within and for the research and education sector or extend beyond it. Wolfram Horstmann, Bielefeld University, explored the many ways to interoperability drawing a number of important conclusions. While interoperability is multi-levelled, a network rather than a layer model is needed. Semantics are a core challenge for Digital Library interoperability. Such a focus would allow the autonomy needed to meet heterogeneous needs. Simplicity is key to the uptake of standards.

The Round Table chaired by Seamus Ross, University of Toronto, brought into sharp relief the need for a far-reaching approach to interoperability, as well as the need to address data management, including the data diversity that exists even within the same discipline. While data management is implemented in several large collaborative infrastructure projects, ownership of preservation and transfer of content remain important questions. Technology in itself is not enough. There needs to be a policy push to enforce the actions required while fostering effective dialogue across a spectrum of organisations.

Links:
http://www.dlorg.eu/
http://www.dlorg.eu/index.php/dl-org-events/digital-library-research-open-access-repositories

Please contact:
Donatella Castelli
ISTI-CNR, Italy
E-mail: donatella.castelli@isti.cnr.it

Call for Participation

FMICS 2011 - 16th International ERCIM Workshop on Formal Methods for Industrial Critical Systems

Trento, Italy, 29-30 August 29/30, 2011; co-located with RE 2011

The aim of the FMICS workshop series is to provide a forum for researchers who are interested in the development and application of formal methods in industry. In particular, FMICS brings together scientists and engineers that are active in the area of formal methods and interested in exchanging their experiences in the industrial usage of these methods. The FMICS workshop series also strives to promote research and development for the improvement of formal methods and tools for industrial applications.

Topics of interest include (but are not limited to):
- design, specification, code generation and testing based on formal methods
- methods, techniques and tools to support automated analysis, certification, debugging, learning, optimization and transformation of complex, distributed, real-time systems and embedded systems
- verification and validation methods that address shortcomings of existing methods with respect to their industrial applicability (eg, scalability and usability issues)
- tools for the development of formal design descriptions
- case studies and experience reports on industrial applications of formal methods, focusing on lessons learned or identification of new research directions
- impact of the adoption of formal methods on the development process and associated costs
- application of formal methods in standardization and industrial forums

The proceedings of the workshop will be published the Springer series Lecture Notes in Computer Science (LNCS). Participants will give a presentation of their papers in twenty minutes, followed by a ten-minute round of questions and discussion on participants' work. Following the tradition of the past edition, a special issue of an international scientific journal will be devoted to FMICS 2011.

More information:
http://events.fortiss.org/fmics2011/
http://www.inrialpes.fr/vasy/fmics/

Call for Papers and Participation

SPIRE 2011 - 18th International Symposium on String Processing and Information Retrieval

Pisa, Italy, 17-21 October 2011

The scope of the SPIRE series of symposia includes not only fundamental algorithms in string processing and information retrieval, but also SP and IR techniques as applied to areas such as computational biology, DNA sequencing, and Web mining. Given its interdisciplinary nature, SPIRE offers a unique opportunity for researchers from these different areas to meet and network.

Typical topics of interest include, but are not limited to:
- String Processing: Dictionary algorithms, Text searching, Pattern matching, Text and sequence compression, Succinct and compressed indexing, Automata-based string processing;
- Biological Sequence Processing: Analysis of DNA and RNA sequencing data, Molecular sequence processing, Recognition of genes and regulatory elements, Comparative genomics and population genetics;
- Information Retrieval: Information retrieval models, Indexing, Ranking and filtering, Interface design for IR, Evaluation issues in IR, Text analysis, Text mining, Text classification and clustering, Information extraction, Language models and topic models for search related-tasks, Efficient implementation of IR systems, Algorithms and data structures for IR;
- Search-related tasks: Cross-lingual information retrieval, Multimedia / multi-modal information retrieval, Recommendation and collaborative filtering, Semi-structured data retrieval, Blog retrieval.

SPIRE 2011 will feature:
- A full day of tutorials
- A three-days' technical program of invited and submitted papers
- A full day of workshops

The deadline for the submission of papers is 20 April 2011.

More information:
http://spire2011.isti.cnr.it/

Competition on Plagiarism Detection, Author Identification, and Wikipedia Vandalism Detection

held in conjunction with the CLEF'11 conference, Amsterdam, Netherlands, 19-22 September 2011

This year's edition divides into three tasks, namely plagiarism detection, author identification, and Wikipedia vandalism detection.

Plagiarism detection in text documents is a challenging retrieval task: today's detection systems are faced with intricate situations, such as paraphrased plagiarism within and across languages. Moreover, the source of a plagiarism case may be hidden within a large collection of documents such as the Web, or it may not be available at all. Building on the successful evaluation framework developed in the last two years, we continue to add new challenges this year.

Author identification is the task of determining the true author of a text. Throughout history and especially today, many texts are written anonymously or under false names, so that readers may not be certain of a text's alleged author. Within author identification, one of the main challenges is to automatically attribute a text to one of a set of known candidate authors. For the

purpose of the evaluation, we have developed a new authorship evaluation corpus.

Vandalism has always been one of Wikipedia's biggest problems. However, the detection of vandalism is done mostly manually by volunteers, and research on automatic vandalism detection is still in its infancy. Hence, solutions are to be developed which aid Wikipedians in their efforts.

We invite researchers and practitioners from all fields to participate.

Important Dates
- Result submission deadline: 31 May, 2011
- Notebook submission deadline: 30 Jun 30 2011

More information:
http://pan.webis.de

Call for Papers

1st EvAAL Competition on Indoor Localization and Tracking

EvAAL (Evaluating AAL Systems Through Competitive Benchmarking) is organizing a series of evaluation campaigns in order to stimulate the development of innovative benchmarking methodologies for Ambient Assisted Living systems.

In the initial phase, the focus is on specific, small scale topics, with the aim of creating a large dataset, reusable for further experiments. In a second phase, it will be possible to evaluate and compare more complex systems. The topic of the 2011 edition is Indoor localization and tracking, a key component for achieving context-awareness in AAL systems. Candidates must submit a paper describing their localization system. Submitters of accepted papers will be invited to compete at the CIAMI Living Lab in Valencia on 25-29 July. The winner will be announced during the AAL Forum (26-28 September 2011) a major event in the field of Ambient Assisted Living in Europe.

More information:
http://evaal.aaloa.org/current-competition/cfc

Call For Papers

IWPSE-EVOL'2011 Joint ERCIM Workshop on Software Evolution and International Workshop on Principles of Software Evolution

Szeged, Hungary, 5-6 September 2011

Research in software evolution and evolvability has been thriving in the past years, with a constant stream of new formalisms, tools, techniques, and development methodologies. Research in software evolution has two goals; the first is to facilitate the way long-lived successful software systems can be changed in order to cope with demands from users and the increasing complexity and volatility of the contexts in which such systems operate. The second goal is to understand and if possible control the processes by which demand for these changes come about.

The IWPSE-EVOL workshop is the merger of the annual ERCIM Workshop on Software Evolution (EVOL) and the International Workshop on Principles of Software Evolution (IWPSE). The rationale for a common event is to capitalize on the synergies to be found when theorists and practitioners meet.

The 2011 edition of IWPSE-EVOL will be held in Szeged, Hungary, as a co-located event of ESEC/FSE'2011, the 8th joint meeting of the European Software Engineering Conference and the ACM SIGSOFT Symposium on the Foundations of Software Engineering.

Topics

IWPSE-EVOL'2011 invites high-quality papers presenting experiments, surveys, approaches, techniques and tools related to the evolution of software systems. Topics of interest include, but are not limited to:
- application areas: distributed, embedded, real-time, ultra large scale, and self-adaptive systems, web services, mobile computing, information systems, systems of systems, etc.
- paradigms: support and barriers to evolution in aspect-oriented, agile, component-based, and model-driven software development, service-oriented architectures, etc.
- technical aspects: co-evolution and inconsistency management, impact analysis and change propagation, dynamic reconfiguration and updating; architectures, tools, languages and notations for supporting evolution, etc.
- managerial aspects: effort and cost estimation, risk analysis, software quality, productivity, process support, training, awareness, etc.
- empirical studies related to software evolution.
- mining software repositories techniques supporting software evolution.
- industrial experience on successes and failures related to software evolution
- interdisciplinary approaches: adaptation of evolutionary concepts and measures from other disciplines (biology, geology, etc.) to software evolution
- theories and models to explain and understand software evolution.

Proceedings of the workshop will be published in the ACM digital library. A selection of the best papers will be considered for revision, extension, and publication in a special issue of an international journal.

IWPSE-EVOL will feature a special event dedicated to the memory of Prof. Manny Lehman, known as the "Father of Software Evolution", who sadly passed away in December 2010.

Important dates:
- Abstract due: 12 May 2011
- Paper due: 15 May 2011
- Notification: 1 July 2011
- Workshop: 5-6 September 2011

IWPSE-EVOL'2011 is co-chaired by Romain Robbes (University of Chile, Chile) and Anthony Cleve (University of Namur, Belgium).

More information:
http://pleiad.cl/iwpse-evol/
http://2011.esec-fse.org/

ERCIM Working Group Software Evolution:
http://wiki.ercim.eu/wg/SoftwareEvolution/

Please contact:
Romain Robbes and Anthony Cleve
iwpseevol2011@easychair.org

German Climate and Environment Innovation Prize for Researchers at Fraunhofer SCAI

A research group from the Department of Optimization at the Fraunhofer Institute for Algorithms and Scientific Computing SCAI won the 25,000 Euro innovation prize for Climate and Environment (IKU) in the "Environmentally friendly products and services" category. The award is donated by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the Federation of German Industries (BDI). The award was handed to the researchers in a ceremony on March 15 in Berlin. Worldwide, over 7,000 companies use the optimization solutions provided by Fraunhofer SCAI. The best known applications are AutoNester (automatic placement of pieces onto textiles, leather, metal sheets and wood) and PackAssistant (optimizing packing configurations of identical parts into containers). The potential savings are enormous: "When cutting metal, wood or leather skins our software saves up to 30 percent of material, depending on the industry," says Dr. Ralf Heckmann, Director of the Department of Optimization at Fraunhofer SCAI.
http://www.iku-innovationspreis.de

E-services for the Elderly at Home

The exponential growth in the ageing population in European countries is raising severe problems for the national health programmes, scrambling to create adaptable solutions for different medical situations and diseases. The “OLDES” project, funded by the 6th EU FP, and coordinated by Massimo Busuoli and Marco Carulli, ENEA, Italy, aimed at tackling some of the challenges that e-Health for the elderly has to face today by implementing an affordable and customisable tele-cardiology system. The OLDES approach, based on a “participative design” concept, has developed an accessible and logical medical platform for the elderly, involving interested actors both in the implementation of the system and in the design/validation phases. The use of a low-cost PC, combined with essential tele-support and telemedicine services, has made OLDES a viable model for future service providers and regional social services interested in setting up a programme for remote diabetes and cardiologic services. To test and validate the OLDES platform, 2 pilots have been implemented: one in Prague focused on 10 diabetes patients and one in Bologna, targeted at 100 elderly (10 with cardiologic diseases).
http://www.oldes.eu

Van Wijngaarden Award 2011 for Éva Tardos and John Butcher

Photo: Peter Lowie

On the occasion of the 65th anniversary of CWI in Amsterdam, the Hungarian computer scientist Éva Tardos and the New Zealand mathematician John Butcher received the Van Wijngaarden Award 2011 on 10 February 2011. The award is intended for scientists who contributed significantly to their fields. Éva Tardos is Schurman Professor of Computer Science at Cornell University in Ithaca, USA. Her research interests comprise algorithms and algorithmic game theory, in which she especially takes selfishness into account. The mathematician John Butcher, Emeritus Professor at the University of Auckland in New Zealand, works on numerical methods for ordinary differential equations. Applications include the simulation of waves. The Van Wijngaarden Award is named after Adriaan van Wijngaarden (1916 – 1987), one of the founders of computer science in the Netherlands.
http://www.cwi.nl/soiree-65-year-centrum-wiskunde-informatica

CWI Spin-off Company VectorWise sold to Ingres

High-tech spin-off company VectorWise from CWI has been sold to Ingres Corporation (USA), a leading open source database management company. VectorWise develops analytical database technology and was founded in 2008 by members of the pioneering CWI database research team: Peter Boncz, Marcin Zukowski, Sándor Héman and Niels Nes. Ingres Corporation has funded the spin-off company since its inception. VectorWise is based on scientific research results and derives its strength from a completely new approach on data processing. The approach makes use of vector processing on data sets in which every vector is tailored to the size of the cache memory of modern processors. The technology of VectorWise allows organizations to perform data analysis tasks that were previously not feasible. Application areas include logistics, science, medicine and healthcare. The development of VectorWise has spurred further scientific innovation, as other scientists around the world are using this state-of-the art system as a foundation for further research. The generation of high-tech spin-off companies is an important method for CWI to convert fundamental knowledge into practical applications.

https://www.cwi.nl/news/2011/cwi-spin-company-vectorwise-sold-ingres-corporation

ERCIM
European Research Consortium for Informatics and Mathematics

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.

AARIT
Austrian Association for Research in IT
c/o Österreichische Computer Gesellschaft
Wollzeile 1-3, A-1010 Wien, Austria
http://www.aarit.at/

CNR
Consiglio Nazionale delle Ricerche, ISTI-CNR
Area della Ricerca CNR di Pisa,
Via G. Moruzzi 1, 56124 Pisa, Italy
http://www.isti.cnr.it/

Crcim
Czech Research Consortium
for Informatics and Mathematics
FI MU, Botanicka 68a, CZ-602 00 Brno, Czech Republic
http://www.utia.cas.cz/CRCIM/home.html

CWI
Centrum Wiskunde & Informatica
Centrum Wiskunde & Informatica
Science Park 123,
NL-1098 XG Amsterdam, The Netherlands
http://www.cwi.nl/

fonds national de la recherche
Fonds National de la Recherche
6, rue Antoine de Saint-Exupéry, B.P. 1777
L-1017 Luxembourg-Kirchberg
http://www.fnr.lu/

FWO
Egmontstraat 5
B-1000 Brussels, Belgium
http://www.fwo.be/

FNRS
rue d'Egmont 5
B-1000 Brussels, Belgium
http://www.fnrs.be/

FORTH
Foundation for Research and Technology – Hellas
Institute of Computer Science
P.O. Box 1385, GR-71110 Heraklion, Crete, Greece
http://www.ics.forth.gr/

Fraunhofer IUK-TECHNOLOGIE
Fraunhofer ICT Group
Friedrichstr. 60
10117 Berlin, Germany
http://www.iuk.fraunhofer.de/

INRIA
Institut National de Recherche en Informatique
et en Automatique
B.P. 105, F-78153 Le Chesnay, France
http://www.inria.fr/

IUA
Irish Universities Association
Cumann Ollscoileanna Éireann
Irish Universities Association
c/o School of Computing, Dublin City University
Glasnevin, Dublin 9, Ireland
http://ercim.computing.dcu.ie/

NTNU
Norwegian University of Science and Technology
Faculty of Information Technology, Mathematics and
Electrical Engineering, N 7491 Trondheim, Norway
http://www.ntnu.no/

PEG
PORTUGUESE ERCIM GROUPING
Portuguese ERCIM Grouping
c/o INESC Porto, Campus da FEUP,
Rua Dr. Roberto Frias, nº 378,
4200-465 Porto, Portugal

Universitas Varsoviensis
PLERCIM
Universitas Wratislaviensis
Polish Research Consortium for Informatics and Mathematics
Wydział Matematyki, Informatyki i Mechaniki,
Uniwersytetu Warszawskiego, ul. Banacha 2, 02-097 Warszawa, Poland
http://www.plercim.pl/

Science & Technology Facilities Council
Science and Technology Facilities Council,
Rutherford Appleton Laboratory
Harwell Science and Innovation Campus
Chilton, Didcot, Oxfordshire OX11 0QX, United Kingdom
http://www.scitech.ac.uk/

SpaRCIM
Spanish Research Consortium for Informatics and Mathematics
Spanish Research Consortium for Informatics and Mathematics,
D3301, Facultad de Informática, Universidad Politécnica de Madrid,
Campus de Montegancedo s/n,
28660 Boadilla del Monte, Madrid, Spain,
http://www.sparcim.es/

Swedish Institute of Computer Science
SICS
Swedish Institute of Computer Science
Box 1263,
SE-164 29 Kista, Sweden
http://www.sics.se/

SARIT
Swiss Association for Research in Information Technology
c/o Professor Daniel Thalmann, EPFL-VRlab,
CH-1015 Lausanne, Switzerland
http://www.sarit.ch/

MTA SZTAKI
Magyar Tudományos Akadémia
Számítástechnikai és Automatizálási Kutató Intézet
P.O. Box 63, H-1518 Budapest, Hungary
http://www.sztaki.hu/

VTT
Technical Research Centre of Finland
PO Box 1000
FIN-02044 VTT, Finland
http://www.vtt.fi/

Order Form

If you wish to subscribe to ERCIM News ***free of charge*** *or if you know of a colleague who would like to receive regular copies of ERCIM News, please fill in this form and we will add you/them to the mailing list.*

Send, fax or email this form to:

ERCIM NEWS
2004 route des Lucioles
BP 93
F-06902 Sophia Antipolis Cedex
Fax: +33 4 9238 5011
E-mail: office@ercim.eu

Data from this form will be held on a computer database. By giving your email address, you allow ERCIM to send you email

I wish to subscribe to the

☐ ***printed edition*** ☐ ***online edition (email required)***

Name:

Organisation/Company:

Address:

Postal Code:

City:

Country

E-mail:

You can also subscribe to ERCIM News and order back copies by filling out the form at the ERCIM Web site at http://ercim-news.ercim.eu/