

# ERCIM



# NEWS

European Research Consortium  
for Informatics and Mathematics  
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## Special theme:

# Towards

# Green ICT

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by Mazin Yousif

*Joint ERCIM Actions:*  
2009 Cor Baayen Award  
to Teemu Roos

*R&D and Technology Transfer:*  
A 3D Event-Based Silicon  
Retina Stereo Sensor

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**Editorial Board:**

- Central editor:  
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  - Portugal: Paulo Ferreira ([paulo.ferreira@inesc-id.pt](mailto:paulo.ferreira@inesc-id.pt))
  - Spain: Christophe Joubert ([joubert@dsic.upv.es](mailto:joubert@dsic.upv.es))
  - Sweden: Kersti Hedman ([kersti@sics.se](mailto:kersti@sics.se))
  - Switzerland: Harry Rudin ([hrudin@smile.ch](mailto:hrudin@smile.ch))
  - The Netherlands: Annette Kik ([Annette.Kik@cwi.nl](mailto:Annette.Kik@cwi.nl))
  - United Kingdom: Martin Prime ([M.J.Prime@stfc.ac.uk](mailto:M.J.Prime@stfc.ac.uk))
  - W3C: Marie-Claire Forgue ([mcjf@w3.org](mailto:mcjf@w3.org))

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**Next issue:**

January 2010, Special theme: "Digital Preservation".



# Towards Green ICT

After years of token recognition, green Information and Communication Technology (ICT) is beginning to gain significant traction. In fact, the association of ‘greenness’ with technology has become so fashionable that companies are now trying to ‘out-green’ each other. The main catalyst for this change is the realization that energy consumption is growing at a staggering rate, far beyond that for which we have prepared. The corollary for ICT is that as an industry, it is responsible for significant environmental impact. For example, it is not uncommon for newly constructed data centres to consume more power than the cities they are located in, forcing data centre deployment decisions to be driven by the availability of either cheap electrical power or a natural means of cooling (eg data centres are being built in Iceland for its low average ambient temperatures). Further, electrical bills to power ICT infrastructure are reaching billions of US dollars, and represent a big percentage of the operational expenses of ICT.

The impact of ICT on the Earth’s climate and its dwindling resources is another major concern. Recent studies found that carbon dioxide (CO<sub>2</sub>) emissions from data centres alone surpass emissions from many individual countries (note that this does not include CO<sub>2</sub> emissions from other global ICT infrastructure). This is in addition to the fact that much ICT equipment contains toxic substances such as lead and mercury, much of which enters the environment via the dumping of obsolete equipment.

Given the above, serious collaboration between technologists, developers, researchers, consumers and politicians is needed to achieve green and sustainable ICT. The ramifications of failing to act would be devastating to the environment, and will lead to electricity bills eating up ever-larger chunks of ICT investment.

As technologists, we have recognized that no single effort is effective enough to make a big dent in ICT energy consumption, mainly due to its extensive and diverse footprint. A combined effort is required, including inter-disciplinary research, industry-wide collaboration and extensive social awareness. The whole fabric of society must be involved, not simply technologists and researchers. Examples of efforts include, but are not limited to:

1. Improving the efficiency of ICT infrastructure through, for example, the use of energy-efficient resources and equipment, allocating the right set of resources to execute workloads given their Service-Level Agreements and deploying technologies such as virtualization and autonomic power optimizations.
2. Developing new technology, such as new materials, lower-voltage equipment, increased integration (eg system-on-a-chip) and power-aware ICT (both hardware and software).



*Mazin Yousif, PhD  
CEO, Avirtec Corporation and chair of the ERCIM Advisory Committee.*

3. Improving the efficiency of ICT operations by, for example, using advanced cooling technology and power generation equipment; adopting best practices and known methods for operating ICT deployments such as physical layout to reduce internal/external heat; and optimizing physical placement of resources.
4. Encouraging conservation: here end-users and consumers of ICT must be motivated to conserve energy through schemes such as placing energy caps on consumption, devising systems of rewards/penalties, and possibly establishing a trading market for energy or emission certificates. For example, if a company exceeds its emission limits, it can buy unused certificates from companies that have succeeded in cutting their emissions. It would also be appropriate to hold IT accountable for the cost of operating ICT infrastructure, as it encourages them to improve efficiency and turn off machines that are not in use. I would even recommend making productivity a function of consumption: ie greater consumption must be associated with higher productivity.
5. Increasing social awareness through policies and communications to explain the urgency of the issue and urge conservation.

The above efforts require that quantifiable benchmarks and metrics be developed to gauge their effectiveness and ensure progress towards established goals.

Another important effort is recycling programs along the ‘reduce-recycle-reuse’ theme. Most computer manufacturers have established plans to take back their obsolete products for free and have devised ways to reduce their footprint on the environment. These manufacturers have also been limiting the amounts of toxic substances like lead and mercury in their products.

In summary, an energy consumption crisis is looming on the horizon. Immediate action is demanded, involving inter-disciplinary research, industry-wide collaboration, policies and social awareness. My message to ICT companies is “Learn how to profit from consumers without harming the environment, as it is more rewarding.” And to the research community “Embark on more effective inter-disciplinary research developing green sustainable ICT technologies.”

*Mazin Yousif*

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## Two New ERCIM Working Groups Formed

*To new ERCIM Working Groups have been established recently: The Working Group "Social Network Analysis" focusing on algorithmic aspects of network data analysis and the Working Group "Models and Logics for Quantitative Analysis" exploring and developing methods for formal verification of modern advanced software systems.*

### Social Network Analysis

The ERCIM working group on Social Network Analysis (SNA) has recently been formed in 2009 with a view to foster European collaboration in research on data analysis for social networks. The main objective of the SNA group is to build a strong network of researchers with expertise on algorithmic aspects of network data analysis. The first action will be to foster collaboration through the organisation of scientific meetings with the medium-term objective of collaborating on funded research programmes in this area.

Research in network data analysis is being transformed by access to large-scale data resources. The availability of this data in electronic format presents some interesting challenges and opportunities for data analysis. In particular, social networking sites are prominent sources of such data. Given that the defining characteristics of social networks are that at least some of the nodes in the network are human actors, the analysis of such networks can be used to provide useful insights into how people interact. However, fundamental research problems exist, and many of these problems are common among several research domains.

Areas of interest include:

- Algorithmic aspects of large-scale networked data analysis
- Information retrieval over social media
- Data mining and semantic web approaches for social media enrichment

The SNA working group sees significant synergies with existing ERCIM working groups such as Computing and Statistics & Data and Information Spaces (DIS).

The initial meeting of the SNA WG attracted 29 participants from nine universities and two industry partners with a keynote lecture from Prof. Barry Smyth of UCD, Dublin. The meeting led to agreement on the name and scope of the working group with a follow-up meeting to be held in Italy in November during ERCIM fall meetings.

#### Link:

<http://wiki.ercim.org/wg/SNA>

Please contact:

Pádraig Cunningham

SNA Working Group coordinator

University College Dublin, Ireland

E-mail: [padraig.cunningham@ucd.ie](mailto:padraig.cunningham@ucd.ie)

### Models and Logics

### for Quantitative Analysis

A new ERCIM Working Group on Models and Logics for Quantitative Analysis (MLQA) was officially established in September 2009. The remit of the Working Group is to explore and develop methods for formal verification of modern advanced software systems. Such methods have already been successfully applied to self-contained and relatively simple systems. The group will develop new methods and expand the applicability of previous methods in order to formally verify the functionality of complex interacting modern software systems. This will be done by combining recent theory and methods from computer science and mathematical modelling.

A large fraction of contemporary Information Technology systems are either Embedded Systems (offering autonomous and intelligent control of complex physical systems) or Service-Oriented Architectures (providing Web services designed to support machine-to-machine interaction over a network). This tendency will greatly increase in what will become the Internet of the Future, an integrated system comprising telecommunications, the Internet, and small systems embedded in domestic appliances. Cutting-edge examples include intelligent vehicles that actively prevent accidents, intelligent homes that actively support your lifestyle, and services for handling electronic shopping and secure pay-

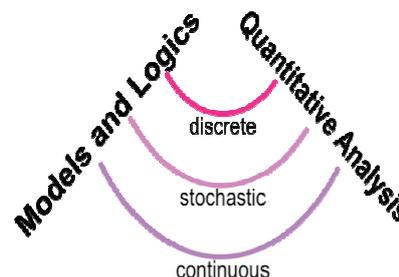


Figure 1: The research challenges of MLQA.

ments. On a larger scale, the future integration of medical equipment, emergency support systems, electronic hospital records and next-generation communication technology are examples pointing towards the trend of Service-Oriented Systems incorporating a number of embedded components. On an even larger scale, we begin to see IT Guided Workflow Systems where the humans mainly play the role of domain experts (eg a doctor who is an expert in a given treatment) rather than being in charge of the overall workflow (eg monitoring the treatment history from the point of view of the patient). Outside the traditional domains of IT systems, the use of computer science modelling and analysis techniques is also growing in the life sciences, in particular the modelling of components of biological systems.

The need for stability in the IT infrastructure of our future society demands that a number of fundamental properties be validated for the IT systems of interest. This spans properties related to security (eg 'no virus can allow outsiders to get access to my Internet banking account'), performance/dependability (eg 'my critical Internet service will be avail-

able 99.99% of the time’) and resource usage (eg ‘the control system rotates and adjusts the windmill such that at least 60% of the potential wind energy is utilized’). Even the formulation of these properties becomes nontrivial when addressing IT Guided Workflow Systems that have humans as ‘subsystems’ and when addressing the description of three-dimensional behaviour in biological systems.

The challenge in the modelling and validation of embedded and service-oriented systems is that due to their interaction with the surrounding physical environment, they must include aspects that are discrete (eg providing security guarantees), stochastic (eg dealing with performance) and continuous (eg providing measurements of resource usage). A shift is required in the development of IT systems from the study of discrete properties to also include stochastic and continuous properties, not least when addressing IT Guided Workflow Systems. The use of stochastic and continuous properties is equally important in the life sciences.

To meet the above challenge we need powerful modelling methods and algorithms for the analysis of discrete, stochastic and continuous properties. The aim of this Working Group is to create both a venue for knowledge sharing in this exciting area and a network for young researchers; furthermore to share tools for performing analyses and to create joint European research projects on quantitative analysis.

The Working Group was created following a meeting/workshop during the ETAPS 2009 conference held in York in March, where 33 participants enjoyed six invited talks and twelve short presentations.

The activities of the ERCIM Working Group on Models and Logics for Quantitative Analysis (MLQA) will study process models that are appropriate for describing the behaviour of systems and logics that are suitable for describing their quantitative properties.

The activities will:

- model behaviour of processes by means of transition systems, automata or process calculi
- model quantitative properties using logics for expressing not only discrete but also stochastic and continuous properties
- focus on algorithms, theory and tools
- study applications with particular emphasis on embedded systems and service-oriented systems, but aim also to treat IT Guided Workflow Systems and biological systems.

**Link:**

<http://wiki.ercim.org/wg/MLQA>

**Please contact:**

Flemming Nielson  
MLQA Working Group coordinator  
DTU Informatics, Denmark  
E-mail: [mlqa@imm.dtu.dk](mailto:mlqa@imm.dtu.dk)

*ERCIM Working groups are open to any researcher in the specific scientific field. Scientists interested in joining the Working Group should contact the coordinator.*

## 2009 Cor Baayen Award to Teemu Roos

*In a tight competition, the ERCIM Executive Committee has chosen Teemu Roos from the Helsinki Institute for*



*Teemu Roos.*

*Information Technology HIIT as the winner of the 2009 Cor Baayen Award for a promising young researcher in computer science and applied mathematics.*

Teemu Roos received his PhD degree from the University of Helsinki, Finland, in September 2007. The title of his thesis is “Statistical and Information-Theoretic Methods for Data

Analysis”. During and after his postgraduate studies, Teemu Roos, has performed groundbreaking research by combining advanced theoretical reasoning with innovative technical solutions in the fields of information theory, data analysis and machine learning. He has attacked and solved practical problems of utmost importance in an unusually wide range of applications. His two equivalence results that establish formal connections between Bayesian network classifiers and logistic regression, and between regularized Haar wavelets and so called variable length Markov chains, can be considered theoretical as well as practical breakthroughs.

Teemu also stated and proved a theorem about the possibility of inductive generalizations to as yet unseen cases under a certain mild stationarity assumption, a result that was formerly claimed, and generally believed, to be impossible in its present form. For this work, he received the best paper award at the Belgian-Dutch Conference on AI in 2005. His highly cited work in mobile device positioning - he has several papers in the field with total citation count exceeding 450 - has been patented and successfully commercialized in the award-winning spin-off company Ekahau Inc. (Frost & Sullivan Technology Leadership Award, European Union Information Society Technology Prize, Software Industry Summit Best Commercialized Innovation in Finland, etc.). As an another example, in collaboration with historians, Roos has gained significant advances in the study of the “evolution” of ancient manuscripts by unprejudiced application of state-of-the-art information-theoretic methods to stemmatology, a long-standing problem in textual criticism.

Teemu Roos has already at this phase of his career demonstrated capability for independent, multifaceted, creative, and highly original work, producing both theoretical and practical solutions of undisputable societal and commercial value. The positioning techniques, some of which he introduced already in his MSc thesis, are being used every day in more than 150 hospitals around the world, and numerous other locations in government, military, and industry. Teemu’s interdisciplinary work on stemmatology, introducing exact mathematical and computational tools in an area where they have been largely

unused, has led to a prolific collaboration rousing both domestic and international interest. This work has already contributed to historical research as reported in at least three books and academic dissertations.

He has also been active in making his scientific work known to the public: he has appeared in the press and television in connection with the stemmatological work. As a young researcher, Temu Roos is already a regular invited speaker and organizer in various scientific workshops. He works fluently with the leading figures in his field, including Prof. Peter Grünwald (Amsterdam), Prof. Bin Yu (UC Berkeley), and the information-theoretist, Prof. Emeritus Jorma Rissanen (IBM Research), the originator of the minimum description length (MDL) principle and the recipient of the 2009 IEEE Claude E. Shannon Award, with whom Temu Roos has co-authored several publications.

Teemu Roos was awarded the Junior Researcher Prize of the Department of Computer Science, University of Helsinki in 2006, and his dissertation was shortlisted for the 2008 North-American Classification Society Distinguished Dissertation Award.

#### 2009 Finalists

From the 36 candidates nominated for the 2009 Cor Baayen award, the ERCIM Executive Committee has accepted 20 finalists (in alphabetical order):

- Ira Assent, Denmark
- Balazs Csaji, Hungary
- Jan Bender, Germany
- Sameh Elnikety, Switzerland
- Beat Fluri, Switzerland
- Ali Ghods, Sweden
- Jakob Gorm Hansen, Denmark
- Charles B Haley, United Kingdom
- Gwenaël Joret, Belgium
- Kristian Kersting, Germany
- Freddy Lecue, France
- Anders Lindgren, Sweden
- Costas Panagiotakis, Greece
- Rodrigo Roman, Spain
- Teemu Roos, Finland
- William Smith, United Kingdom
- Oscar Deniz Suarez, Spain
- Manuel Wimmer, Austria
- Tom Van Cutsem, Belgium
- Akrivi Vlachou, Greece.

The winner, Teemu Roos, was selected by the ERCIM Executive Committee on advice from the ERCIM Advisory Committee.

#### About the Cor Baayen Award

The Cor Baayen Award is awarded each year to a promising young researcher in computer science and applied mathematics. The award was created in 1995 to honour Cor Baayen, the first president of ERCIM and the ERCIM 'president d'honneur'. The award consists of a cheque for 5000 Euro together with an award certificate.

#### More information:

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

## EUROINDIA International Events

by Ashok Kar, Nick Ferguson and Florence Pesce

*The Euro-India ICT Cooperation Initiative ('EUROINDIA') is a Support Action under the Seventh Framework Programme. This initiative aims to reinforce collaborative research and innovation activities between Indians and Europeans in ICT domains and challenges targeted in the EU's FP7. EuroIndia organized a series of events in India during August and was also invited to conduct a thematic session within the eIndia Conference.*

#### Information Days

The first Information Day was held in Chennai on 25 August at the prestigious Indian Institute of Technology (IIT Madras) campus, with participants hailing from academia/research. The second was on 26 August in the Software Technology Parks of India (STPI) premises in Hyderabad, and catered mainly for participants from industry. Both events offered participants a comprehensive understanding of FP7 (2007-2013) and the ICT Work programme 2009-10, with a particular focus on the Call 5 and how Indians can engage in research projects alongside European partners. EuroIndia representatives were also on hand to respond to specific individual questions.

#### Chennai Brainstorming Session

A brainstorming session was held in Chennai on 25 August at the IIT campus with the support of the Humanities and Social Sciences Department. The discussion topic for participants – who were mostly academics and researchers – was e-learning, which is emerging as an innovative research area for ICT in India.

Professor Hema Murthy from the TeNet Lab at IIT Madras, who has pioneered rural ICT innovations through a combination of cutting-edge technology and creative content development, shared with participants her extensive experience of e-learning. Professor Murthy, despite having created a robust and scalable e-learning tool of immediate relevance to rural students, nevertheless painted a picture of disappointment. She lamented the absence of physical infrastructure to provide access to computers and communication equipment, and of a viable and scalable business model to enable rural youth to enter the mainstream equipped with education and employability.

The session closed after a rich debate on societal priorities and the consequent focus of e-learning innovations across the complementary objectives: curriculum-based learning, knowledge acquisition and employability.

#### EuroIndia Session at eIndia, Hyderabad

EuroIndia-ICT was a supporting partner of India's largest ICT Event, eIndia2009, held in Hyderabad, India, 25-27 August 2009. During the past twenty months, EuroIndia has developed a knowledge-mapping study methodology and has catalogued publicly reported ICT innovations in India over the period 2003-2007.



From left: Nick Ferguson, Ashok Kar, Sudhanshu Rai, Florence Pesce, John Bosco Lourdasamy, Mogens Kuehn Pedersen at the Info Day Chennai on 25 August 2009 at the Indian Institute of Technology.

Prof. Mogens Kuehn Pedersen from the Copenhagen Business School opened the session, which deliberated on the results of the mapping modules, focusing on key emerging trends and putting them in perspective with the EU's research and innovation trends in ICT. Dr. Sudhanshu Rai, Copenhagen Business School, then led a discussion on the management of innovation. Raj Datta, CKO Mindtree Consulting, shared his insights on challenges surrounding innovation in India, while innovation in the e-learning sector and views on integrating ICT technology into education in India were presented by Ashish Garg, Asia Regional Coordinator - Global e-Schools and Communities Initiative. Finally, Ranjan Malik, partner in Erehwon Innovation Consulting, presented the challenges and opportunities in managing innovation in ICT firms in India. These presentations are available on the EuroIndia portal. The workshop was attended by over 30 participants.

#### Upcoming Events: EuroIndia International Conference

The final EuroIndia International conference will be hosted by the International Management Institute on 10-11 December 2009 in New Delhi. The event will be divided into three sections:

- Presentation of the findings of the two-year extensive mapping conducted across India. Thematic strengths and trends will be developed by experts from India and Europe.
- Presentation of international academic papers on ICT innovations, focusing on collaborative endeavours between the EU and emerging economies, especially India.
- An exhibition in which some of the Indian enterprises and organizations revealed through the EuroIndia knowledge mapping will showcase their innovations and seek to develop collaborative ventures and projects with the EU.

While participation is free of charge, online registration is mandatory. The agenda and registration form will be available on the EuroIndia and ERCIM Web portals. If you would like to participate, please contact [info@euroindia-ict.org](mailto:info@euroindia-ict.org).

The EUROINDIA project is coordinated by the Department of Informatics at the Copenhagen Business School, Denmark. ERCIM is a partner in this project.

**Link:** <http://www.euroindia-ict.org/>

#### Please contact:

Florence Pesce, ERCIM Office  
E-mail: [florence.pesce@ercim.org](mailto:florence.pesce@ercim.org)

## D4Science-II - An e-Infrastructure Ecosystem for Science

*D4Science-II started on 1 October 2009 as one of the main European e-Infrastructure projects, involving ten participants including the European Organisation for Nuclear Research (CERN) and the Food and Agriculture Organization of the United Nations (FAO). Co-funded by the European Commission's Seventh Framework Programme for Research and Technological Development, the D4Science-II project held its kick-off meeting 13-16 October 2009 in Pisa, Italy.*

D4Science-II aims to continue the path that the GEANT, EGEE, DILIGENT and D4Science projects have initiated towards establishing networking, grid-based and data-centric e-Infrastructures. The ultimate goal of this chain of work is to provide scientists with virtual research environments for unlimited generation and dissemination of scientific and technical knowledge.

The project will bring together several scientific e-Infrastructures established in the areas such as biodiversity, fishery and aquaculture resources management, and high energy physics, to set up a prototypical instance of an e-Infrastructure ecosystem.

According to Donatella Castelli, scientific coordinator, CNR, "Individual resources will be harnessed and aggregated for a multiplicative effect on information availability, processing power, and more importantly scientific perspective: the much desired Knowledge Ecology finally obtains life within and is fed by e-Infrastructure ecosystems".

The D4Science-II ecosystem will include among others, the GENESI-DR and DRIVER repository e-Infrastructures, and important thematic repositories maintained by international organisations, e.g. INSPIRE and AquaMaps. The project will create Virtual Research Environments that will offer significantly enhanced services to scientists without incurring high development and maintenance costs.

The primary clients of these Virtual Research Environments serving specific scenarios will be researchers, decision-makers, international and government officers, and non-governmental organisations worldwide.

Scientific coordination of D4Science is headed by CNR while the management of the project is ensured by ERCIM.

#### Link:

<http://www.d4science.eu>

#### Please contact:

Donatella Castelli  
D4Science II scientific coordinator  
ISTI-CNR, Italy  
E-mail: [donatella.castelli@isti.cnr.it](mailto:donatella.castelli@isti.cnr.it)



# Energy Savings in ICT and ICT for Energy Savings

Introduction to the Special Theme

## Towards Green ICT: in ICT and Energy Savings

by Laurent Lefèvre and Jean-Marc Pierson

Energy concerns have been developing now for several years, and the ICT domain cannot escape from this trend. As the title of this special issue suggests, we have gathered here articles reflecting two aspects of the links between energy and ICT.

On the one hand, ICT plays a daily part in the production and use of electricity, from the operation of power plants to electricity transport. More interestingly, ICT is used to model, simulate and optimize these processes. The use of ICT to improve energy efficiency and reduce costs is the subject of a number of papers in this special theme.

On the other hand, ICT itself uses a lot of electricity, and work has begun on reducing the consequent economic and ecological costs. It is estimated that the 1.5 billion computers in the world consume about 90 000 MW of electric power, which is about 10% of global consumption. Some surveys commissioned by the European Union in 2006 on energy use and the efficiency of equipment in buildings tell of a continuous growth in recent years in energy consumption of computer end-use equipment (amongst others). Additionally, energy consumption for servers worldwide has doubled over the period from 2000 to 2005. Recent estimates at the CeBit forum 2008 in Hanover, the world's largest technology fair, proclaimed that worldwide Internet usage, via the necessary computers and servers, needs the equivalent of fourteen power stations and produces the same amount of carbon dioxide as the entire airline industry.

As an example, an operational Grid such as EGEE (Enabling Grid for E-sciEnce) consists of around 150 000 cores distributed over 54 countries and 267 sites ([www.eu-egee.org](http://www.eu-egee.org), October 2009). The world's 500 most powerful machines ([top500.org](http://top500.org), June 2009) have more than 3.1 million processors. Number one on the list (RoadRunner from the United States Department of Energy) con-

sumes 2483 KW of electricity while number two (Jaguar from Oak Ridge National Laboratory) consumes 6950 KW! With new Petaflop data centres in the offing, these energy costs are expected to increase significantly.

As large-scale distributed systems reach enormous sizes, the issue of energy consumption is becoming one of the primary challenges for large-scale integration.

There has traditionally been a dearth of eco-awareness in the computing industry. Moore's Law has not led to the overall power savings that miniaturization should allow. Instead, greater capacity and capability have invariably taken precedence over eco-concerns. Despite the fact that it has now been several years since makers of mobile and embedded systems began to take energy use into account, ecological concerns have not been prioritized in assessing the total collective costs of large-scale distributed technology. Constructors have worked on addressing individually the numerous components of computer architecture, but usage (in networking, storage and computing) has long been ignored.

Ecological impacts constitute a silent cost which until recently received little attention. However, new studies commissioned by government institutions will consider energy efficiency procedures for servers and data centres. White papers exist to establish better use of ICT infrastructure. Strategic issues in the management of such infrastructure and the benefits to economy and enterprise image are being investigated. Another aspect is the continuous raising of public consciousness of the need to save energy and reduce global consumption. Exposing electricity consumption visually to consumers (including by marketing) is an objective targeted by several projects.

Interest in the energy-saving theme from both governments and researchers has increased exponentially in recent years. In early 2000, work done in the USA (Green Destiny) and Japan launched sparked initial interest in energy-aware computing. Recent initiatives such as Green Internet and Green500 have addressed this problem. The Green Grid, a non-profit trade organization involving over fifty major companies (including Intel, AMD, Dell, IBM and VMWare) is dedicated to advancing energy efficiency in data centres and business computing ecosystems. It develops standards, metrics, processes and technology to improve performance, and promotes their widespread adoption. Additionally it investigates approaches that rely most of the time on more energy-efficient hardware and electronics (in particular power supplies).

Surprisingly, European environmental research themes are not yet investigating the issues related to electricity consumption in IT. The environment theme of the FP7 (Framework Programme 7) focuses its actions on environmental issues and climate change, but ignores ICT.

However, the energy theme is concerned with energy consumption and production, and has several projects that use ICT. In the ICT theme, Challenge 1 on pervasive and trusted network and service infrastructure and Challenge 6 on mobility, environmental sustainability and energy efficiency address this question. These programmes have at least raised a number of projects with some eco-awareness. For example, the Virtual Home Environment (VHE) project, a specific subproject of the European Network of Excellence Euro-FGI is looking at energy-efficient home networking, and the AIM and BE-AWARE projects (answers to the ICT-2007.6.3 ICT call for environmental management and energy efficiency) are investigating complementary approaches with different perspectives for eco-awareness. National research initiatives (like EcoGrappe or GreenNet projects in France) also address the issue of energy savings in ICT.

Recently, the European COST Action IC0804 (Energy efficiency in large-scale distributed systems) is giving a voice to this theme (<http://www.cost804.org/>). The aim of this action is to encourage researchers in this field to cooperate and build on common research topics.

The papers presented in this special issue are divided into five groups. The issue begins with (1) some general considerations, strategic issues and the rise of eco-awareness (six papers), followed by a (2) couple of papers on efforts in electronics, and on (3) data centres and clusters (two papers). A significant number of contributions represent (4) advances in IT methodologies and developments towards eco-friendliness (eight papers), especially in large-scale distributed systems. Finally, the issue closes with four papers dealing with (5) the usage of ICT as a means of saving energy.

**Please contact:**

Laurent Lefèvre  
INRIA, University of Lyon, France  
E-mail: [laurent.lefevre@inria.fr](mailto:laurent.lefevre@inria.fr)

Jean-Marc Pierson  
IRIT, Université Paul Sabatier, Toulouse 3, France  
E-mail: [pierson@irit.fr](mailto:pierson@irit.fr)

**"Green ICT" Conferences**

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A list of relevant conferences focused on green computing and energy-aware computer and network architectures and technologies, or containing tracks on these topics is maintained by Jordi Torres and Josep Lluís Berral García, Technical University of Catalonia (UPC) at <http://www.greenit-conferences.org/>

# ICT and Energy: Some Methodological Issues

by Bernard Aebischer

*Technological innovations have wrought many transformations on society. The steam engine opened the way to the industrial society and the aeroplane revolutionized travel. Now, from the telephone to the internet, ICT is putting us on the path to a fully interconnected and radically different world.*

However, with the advent of climate change, the next transformation to society may be driven by environmental considerations and the need to reduce energy consumption. Determining the contribution of ICT to global energy use is complex and difficult. The present article considers several ways of approaching an answer.

## What does ICT comprise?

ICT is usually thought of simply as end-use devices such as computers, other office equipment, entertainment electronics and telephones, with the infrastructure required by this equipment being neglected. But this hidden infrastructure (eg the servers that provide Internet services and the radio antennas necessary to make mobile phone calls) now represents a significant and increasing fraction of ICT electricity consumption.

Even all this end-use equipment and related infrastructure represents only a small fraction of the microprocessors produced and used in industrial processes, buildings, appliances or cars. Rejeski (Anticipations. In "Sustainability at the speed of light", 2002) said that "...only 2 percent of the approximately 8 billion microprocessor units produced last year ended up in computers." And "...there could be as many as 10,000 telemetric devices per person in the industrialised countries by 2010." And "Within a decade more things will be using the internet than people. As Michel Mayer, the head of IBM Pervasive Computing recently noted". Turley (Motoring with microprocessors, 2003) wrote that "...the average middle-class American household includes over 40 embedded processors. About half are in the garage.... Your transportation appliance probably has more chips than your internet appliance... New cars now frequently carry 200 pounds of electronics and more than a mile of wiring".

These observations are important for the estimation of the energy demands of

ICT and essential for evaluating the impact of ICT on society's energy requirements. And whenever investment figures for ICT are quoted, the categories of ICT included in these investments should be clearly stated.

## Direct electricity demand of ICT

Taking into account the end-use equipment described above and its related infrastructure (servers, routers, switches for the Internet, base station switching units and others for telecommunication), typical calculations for an industrialized country suggest ICT accounts for about 5% of total electricity demand.

Knowing that the majority of microprocessors are in applications other than this equipment, we assume a doubling of the electricity demand for ICT. The resulting 10% is of the order of 1 megawatt hour (MWh) per capita and year. 1 MWh/year is a considerable amount of electricity in an industrialized country and it is more than what is used in many countries in the southern hemisphere. This is of course a very rough estimate, but we believe its accuracy to be sufficiently good for us to use it as a basis for the qualitative considerations in this paper.

## Impact of ICT on energy demand

As well as measuring the direct energy demands of ICT equipment, it is also necessary – though much more complex – to determine the indirect impact ICT has on the overall energy demand of a country. To do so, one must consider:

- energy demand over the life cycle of different types of equipment, ie in addition to the direct energy demand discussed above, the energy for producing, distributing and refurbishing or recycling this equipment
- efficiency improvements as a result of the ICT in technical and economic processes; of vehicles and mobility in general; and of buildings, appliances and other energy-consuming activities
- structural changes of and within the economy, substitution between serv-

ices, dematerialization of the economy, and

- acceleration of economic growth thanks to better productivity and rebound effects.

There are two approaches to studying the effect of ICT on energy demands. One is a microeconomic approach consisting of a bundle of case studies, where the impact of ICT on specific services and on the energy intensity of each service is analysed. The other is a macroeconomic approach, where the impact of ICT on the economic growth and on the energy intensity of the economy is investigated.

Most of the case studies to date investigate one of the following fields:

- manufacturing or technical processes
- building automation and intelligent homes
- traffic management
- e-economy with e-commerce, e-work, e-learning and e-governance.

The domain of manufacturing and technical processes is the only one in which most studies agree that ICT substantially reduces energy input.

Automation in buildings clearly has great potential to reduce energy use, particularly in large and complex buildings in the service sector. Information systems are implemented and used in modern buildings, but we know of many examples where the many thousands of data gathered and stored by these systems are not exploited to optimize energy use. In single family houses, 'intelligent systems' tend to lead to an increase in energy services and to a corresponding increase in energy demand (Aebischer and Huser, 2000, 2003).

Much time and energy is wasted in traffic jams. ICT can make traffic more fluid but at the same time it increases traffic flow – as when building a new road in order to decongest an existing one.

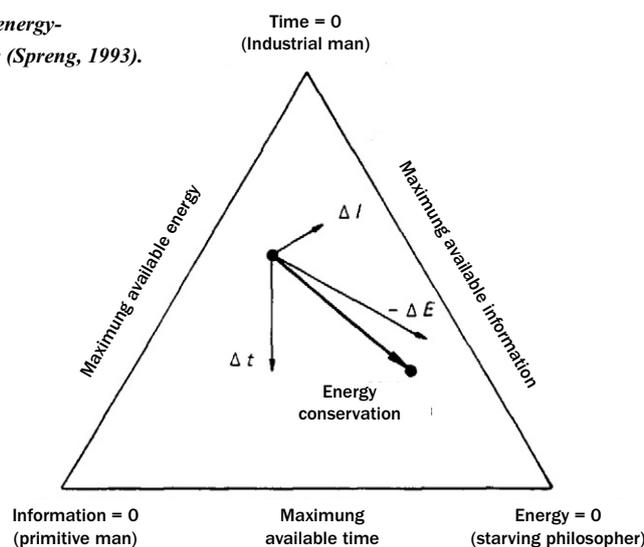
Most of the case studies investigate the impact of increased use of ICT in specific sectors of the economy. New organizational forms (e-work, e-commerce) and new products (e-paper, e-governance) are compared to traditional services and processes. Most of the studies do not question whether there is really a substitution between the traditional and the new service, and/or whether time and money saved by these new processes and services may lead to new energy consumption that balances or even negates the original savings.

#### An alternative approach:

##### Spreng's triangle

An alternative conceptual framework with which to examine the question of the impact of ICT is Spreng's triangle (Spreng, 1993). Spreng describes all economic activity in terms of time, energy and information. The precondition is that there is perfect substitutability between the three factors. Then information can be used to replace time, accelerating innovation cycles and increasing productivity without increasing energy demand. Information can just as easily substitute for energy (or natural resources) without increasing the time, labour or capital input. In reality however, a saving of time (or increased productivity) through more information tends to increase energy demand, whereas more rational use of energy thanks to information may demand more time (see Figure).

Figure 1: The time-energy-information triangle (Spreng, 1993).



Spreng writes: "The importance of new information technology, NIT, in respect of future energy use can hardly be overstated. However, NIT can do two things. It can be used to substitute time by information or to substitute energy by information. NIT can, in other words, both be used to speed up the pace of life (work and leisure), thus promoting a society of harried mass consumers, or it can be used to conserve precious natural resources (energy and non-energy) by doing things more intelligently and improving the quality of life without adding stress to the environment. It is up to the society as a whole, politics of course included, to decide which of the two roads are taken." (Spreng, 1993).

#### Link:

A more comprehensive and detailed essay "ICT and energy: methodological Issues and Spreng's triangle" with illustrations and literature references can be found in "The European e-Business Report 2008", p. 265: [http://www.ebusinesswatch.org/key\\_reports/documents/EBR08.pdf](http://www.ebusinesswatch.org/key_reports/documents/EBR08.pdf)

#### Please contact:

Bernard Aebischer  
CEPE, ETH Zurich, Switzerland  
Tel: +41 44 632 41 95  
E-mail: [baebischer@ethz.ch](mailto:baebischer@ethz.ch)

## Key Challenges for Green Networking

by Ulrich Barth, Patty Wong, Didier Bourse

**As a leader in telecommunications, Alcatel-Lucent recognizes the important role our industry must play in the global effort to address environmental issues such as climate change. This article highlights some of the corporation's major research and development initiatives.**

Alcatel-Lucent products are thoroughly evaluated for energy efficiency to ensure they support service providers' efforts to reduce the carbon emissions of new and existing networks. As part of its efforts to create exceptional value for its customers, Alcatel-Lucent committed itself to improving the energy efficiency of key products by at least 20% by the end of 2010 compared with 2008. In addition, Bell Labs scientists and engineers are creating innovative solutions and services that provide significant envi-

ronmental benefits in a variety of business sectors, including smart metering, smart buildings, smart transport and tele-working.

Alcatel-Lucent uses an end-to-end approach to energy efficiency in access, transport and core networks. For example, solutions for eco-sustainable wireless networks address all hardware, software, site and subsystem levels. As a result of this holistic strategy, customers benefit from tangible business

and environmental benefits, including dramatically reducing their electricity bills, minimizing their carbon footprint, developing new revenue-generating opportunities through the availability of affordable alternative energy, and potentially expanding their business opportunities with carbon-reducing communication services.

In February 2009, Alcatel-Lucent announced the Dynamic Power Save feature on its GSM/EDGE mobile net-

working portfolio. This new feature reduces power consumption when traffic drops, with real-time reactivity that guarantees no impact on service quality. This reduces average power consumption by 25-30% and can be installed on all of the 500,000 Alcatel-Lucent base stations deployed since 1999, thus protecting mobile operators' investments and making existing networks more energy efficient.

Alcatel-Lucent pioneered the combining of different types of wireless base stations to help customers save energy. The arrays of small coverage area (pico) base stations, strategically combined with a few large coverage area (macro) base stations in mixed deployments can be significantly more energy efficient than networks based on a single technology. Researchers have determined that the total network energy consumption can be reduced by up to 60% in urban areas for high data-rate user demand based on today's technology. Benefits could be as high as a 70% reduction in energy consumption as both technologies mature and the demand for high data rates increases.

In July 2009, Alcatel-Lucent introduced the industry's first 100 Gigabit Ethernet service routing interface for the edge, to help service providers around the world meet massive bandwidth demands. Service providers must minimize space and power requirements if they are to contain costs and maintain an environmentally friendly operation. Alcatel-Lucent's FP2 silicon innovations and improvements in thermal efficiency reduce power consumption to levels approaching four watts per gigabit with the new 100 Gigabit Ethernet interface modules, a significant improvement compared to the 10 Gigabit and 40 Gigabit alternatives widely deployed today.

With 300 solar-powered wireless sites, Alcatel-Lucent has established an industry-leading Alternative Energy Programme. The programme's goal is to develop the world's first integrated, mass-produced, alternatively powered wireless base stations, making it possible for operators to extend the reach of their wireless services to access a huge population of potential new subscribers for its customers – the more than one billion people living in areas not served by an electrical grid. Intended for

worldwide deployment, these hybrid stations powered by wind, solar and bio-fuel cells will be available as turnkey offerings, with faster delivery times and a higher return on investment than can be achieved with the fragmented, site-by-site solutions currently available on the market. The programme brings together the benefits of Alcatel-Lucent's experience in integration and implementation, the power



*Alcatel-Lucent alternative energy pilot site in Villarceaux, France.*

efficiency of its base stations and its professional services. The operational launch of the world's first alternative energy laboratory and pilot site, located on the Bell Labs research site in Villarceaux, France, was announced in June 2009.

Alcatel-Lucent Bell Labs is also researching new ways to improve thermal management performance while reducing the energy required to cool the equipment. These include thermal interface materials to conduct heat, vapour chambers to spread heat and heat sinks to dissipate heat into the air stream.

Through its participation in the European research cooperation framework, Alcatel-Lucent is a key partner in the EC FP7 ADDRESS Integrating Project (IP). This project is working on a technical and economic solution to 'active demand', which means enabling consumers to proactively interact with the power system market, by means of real time interaction based on price and

volume signals and by promoting the exploitation of sources of renewable energy and the development of a distributed generation model.

Alcatel-Lucent Bell Labs is currently coordinating the preparation of the major EC FP7 EARTH IP, (EARTH: Energy Aware Radio and neTwork tecHnologies) addressing 'Green Networking'. The target of the project is to cut the energy use of mobile cellular networks by a factor of at least two. The project will investigate the energy efficiency limit that is theoretically and practically achievable whilst providing high capacity and uncompromised quality of service. The project is primarily focused on the future 3GPP mobile cellular systems LTE and LTE-A (Long Term Evolution-Advanced), where the potential impact on standardization is envisaged, but will also consider currently deployed 3GPP technologies (UMTS/HSPA) for immediate impact. The project will mobilize a consortium of major stakeholders to develop a new generation of energy-efficient products, components, deployment strategies and energy-aware network management solutions.

The tangible results of the research project will include (i) energy-efficient deployment strategies, (ii) energy-efficient network architectures, (iii) new network management mechanisms that adapt to varying loads, (iv) innovative component designs with energy-efficient adaptive operating points, and (v) new radio and network resource management protocols for multi-cell cooperative networking. The new techniques will be validated using sophisticated simulation tools and in a mobile network test plant. The project will provide valuable and timely contributions to standardization and regulations processes.

**Link:**

<http://publications.epress.monash.edu/doi/pdf/10.2104/tja09004>

**Please contact:**

Didier Bourse  
Alcatel-Lucent Bell Labs, France  
Tel: +33 1 3077 6087  
Email:  
[Didier\\_Arnaud.Bourse@alcatel-lucent.com](mailto:Didier_Arnaud.Bourse@alcatel-lucent.com)

# Design for Energy Awareness

by Christina Öhman

*The development of new solutions for better energy use often starts with technology rather than the perspective of the user. Researchers at the Interactive Institute in Sweden do the opposite and look at design which supports awareness and behavioural changes – both important factors with high potentials.*

Interactive Institute is an experimental IT research institute which combines expertise in art, design and information technology with a user-oriented focus. Several projects in the area of energy and design have generated results that are acknowledged worldwide.

Energy is an increasingly valuable resource. However, in the design of everyday domestic environments, buildings and products, electricity and energy use is seldom made explicit. On the contrary, wiring, electrical meters, outlets and batteries are hidden away as much as possible inside walls, in elegant cas-

es of choices available to them and providing them with immediate feedback. In such studies, researchers explore users' behaviour, attitudes and lifestyles in relation to energy use.

“Today most arrangements are focused on technology. But actually, the user is more interesting! The potential is tremendous if we can act, buy and support energy smart,” states Kenneth Asp, specialist at the Swedish Agency of Energy which supports the research of Interactive Institute. “A multidisciplinary approach with a human perspective is needed in order to develop new

petition. The most widely published and acknowledged project is Static!. This project developed ways of experiencing energy that involve all the senses, allowing people to reflect on their energy use and behaviour by creating alternative designs that in various ways expose and provoke questions related to energy. The studies have resulted in a series of examples of how everyday products may be designed to stimulate reflection on daily or long-term patterns of energy use. For example, the ‘Power-Aware Cord’ is an electrical power strip in which the cord is designed to show the energy rather than hiding it. The more energy that passes through the cord, the more it glows! It is beautiful and it is a constant reminder that energy is being spent. Another example is bathroom tiles which are decorated with patterns in a thermo-chromatic ink that reflects hot-water use by fading away when hot water is splashed on it. The ‘Energy-Aware Clock’ centrally placed in the kitchen gives intuitive feedback on the electricity load of the house. The clock draws a graphic pattern in real time comparable to yesterday's use.

The plan for future extended studies is to look further into behaviour at work and in shops. In these spaces people report that they need help to reflect on their environmental impact. We know that both consumers and companies are interested in services and tools that help to decrease emission, energy use and ecological footprints. We believe user-oriented design and interaction designs have great potential for such applications.

## Links:

<http://www.tii.se/static>

<http://www.tii.se/energydesign>

<http://www.tii.se/dru>

## Please contact:

Christina Öhman

Interactive Institute, Sweden

Tel: +46 8 6331751

E-mail: [christina.ohman@tii.se](mailto:christina.ohman@tii.se)



*The ‘Energy Aware Clock’ gives intuitive feedback on the electricity load of the house.*

ings and in distant basements. The trend is to fill the home with smart technology and appliances for communication and entertainment with no concerns in relation to energy. How can consumers become more engaged and less wasteful in this environment? We think the answer lies in design that makes energy use visible in an attractive fashion!

The overall goal in our projects is to empower people in their use of products and services by increasing the visibility

and better technology design. Engineers, architects, behavioural scientists and designers are working together. Prototypes and scenarios of various use concepts are evaluated by users and designers, to develop a profound understanding for, and awareness of, design issues related to energy use.”

Projects in this area at the Interactive Institute cover energy studies relating to teenagers, products, neighbourhoods, social status, mobile phones and com-

# Who Makes IT Professionals Environmentally Aware?

by Andy Phippen

*Research at the University of Plymouth has shown encouraging indications that the next generation of IT professionals is willing to take environmental responsibility seriously. With awareness and the opportunity to reflect, it would seem that students are ready and willing to engage with the sustainability agenda. However, the research also highlights the responsibility of higher education institutions to provide a computer science curriculum that addresses more than simply technical and theoretical knowledge.*

The IT industry is, quite rightly, criticized for its contribution to carbon emissions and for not taking its responsibility to the environment seriously. The sector contributes around 2% of global greenhouse gas emissions, a similar proportion to the aviation industry, and its contribution is growing and will continue to increase as the world's industries become increasingly reliant on large-scale data centres and outsourced services. Yet green IT still seems to be a minority interest in corporate IT.

However, the fault may not lie with practitioners but with educators. Until recently education and recruitment into the IT sector has been based solely on technical ability and problem-solving skills. Only in the last few years has the visibility of the sector been such that social responsibility has become an important issue. This is partly the result of the widespread social and corporate adoption of ICT.

One might argue, therefore, that the current generation of IT professionals was not equipped by their professional development to effectively reflect upon the social implications of the technology and services they develop. The next generation will not have this excuse. Given that IT is now arguably a graduate-level profession, it should fall to the universities to take responsibility for educating their students not just in the technical and theoretical aspects of the subject, but also the wider issues of professional practice and social accountability.

In early 2009, a study at the University of Plymouth, UK, evaluated the willingness of final-stage IT students to engage with environmental issues. These students were coming to the end of their studies and had at least two and a half

years' learning in IT-related subjects, most of which had been technical. In addition, many had been on industrial placements, so had first-hand experience of the sector.

The students were given lectures on sustainability in general, considering the implications of carbon emissions and climate change, and then on the responsibility of the IT sector, including issues such as power consumption and the impact of waste electrical equipment. They were then set that task of writing a reflective report on their own career aspirations within the sector, by drawing on recent news stories from the industry press that made them consider issues of sustainability.

Content analysis of the reports showed a number of encouraging issues emerging from the students' reflections on their role in the future IT sector:

1. There is a lack of awareness of the sustainability issues associated with IT. The most frequently recurring theme was that students had never really considered the environmental implications of their chosen career path during their degree and work to date.
2. Students are environmentally aware and can relate green IT to their own feelings of social responsibility. A number of students stated that they would think carefully about working for a company without a green IT policy now they had become aware of the importance of these issues.
3. They view green IT as a problem that can only be solved by hardware. Several students commented that, because they wished to become software developers, they could not see

how they could contribute to the green IT agenda.

4. They can see the PR potential in green IT. Demonstrating awareness of the value of good PR, some students felt that knowledge of green IT might be good in order to make them more attractive to potential clients.

The results of the work show some very encouraging implications for the future IT workforce, in that once made aware of environmental issues, they are keen to engage. However, it also places the onus very much on educators to ensure this awareness is promoted at an early stage. At Plymouth there is a strategy to bring ethical considerations and professional practice into the curriculum at an early stage, and to ensure there is continuity of education around social responsibility and the means to develop these concepts alongside more complex technical issues. However, in comparing the computer science curricula at other institutions, we find this seems to be the exception rather than the norm.

If we are to generate widespread change within the IT workforce, social responsibility and ethical practice needs to lie at the heart, rather than at the periphery, of the computer science and IT curriculum. Encouragingly, it seems that if their institutions give them the opportunity, students are willing to engage.

#### **Please contact:**

Andy Phippen  
School of Management, University of Plymouth, UK  
E-mail: [andy.phippen@plymouth.ac.uk](mailto:andy.phippen@plymouth.ac.uk)

# Combine Cost Optimization and Energy Efficiency Targets in your IT Strategy: The Going Green Impact Tool Supports You

by Hannes Engelstaedter

The Going Green Impact Tool (GGIT) provides a fast and comprehensive insight into the key environmental and economical aspects of data centres, allowing executives to make faster and better decisions on cost-saving potentials, business continuity and long-term IT strategies. The tool allows different dynamic scenarios to be run, which include simulating various business risks and visualizing the impact of green solutions on energy efficiency, Total Cost of Ownership (TCO) and business continuity.

In times of economic crisis, IT executives must deal with severe organizational budgetary cuts while trying to manage their business portfolios. At the same time, concerns about rising energy demands, escalating electricity prices and greenhouse gas emissions are limiting growth of information technology (IT) business areas and IT service providers. Up to this point, the focus has been on meeting the rapidly increasing computing demand. New high-performance and high-density IT equipment has been deployed, doubling the energy consumption of data centres between 2000 and 2005. However, this development is accompanied by urgent new concerns: rising energy consumption and electricity costs will cause operating expenses to exceed server capital expenses by 2009. According to research studies, power and cooling limits were reached in 50% of the world's data centres by the end of 2008. Governments, in particular in the EU and the US, are working on new legislation for environmental protection, affecting all operations – including IT products – that cause emissions of CO<sub>2</sub> or other greenhouse gases. Furthermore, because of the prominence of global warming concerns, green IT is becoming part of Corporate Social Responsibility (CSR) for any company. Chief Information Officers (CIOs) and other executives therefore face the challenge of developing an IT strategy to minimize those risks, to become more energy efficient, and to reduce operating and investment costs to ensure the company's growth.

Fortunately, there already exist solutions to improve the energy efficiency of data centres and reduce risks, while enabling CIOs to meet expanding business needs on a shrinking budget. However,

because of the diversity of design and requirements of data centres, there is no single perfect strategy. Depending on

the issues, one must choose from a long list of possible solutions, which vary by impact, cost and sustainability. While



Screenshot of the Going Green Impact Tool.

there are tools to aid this choice, most are either too technical or too specialized to assist the CIO or other executives in mastering the challenges of becoming energy efficient.

To determine the most effective strategy, CIOs need to develop a holistic view. They must not only focus on energy-related issues but also assess the situation from an economic point of view and with a long-term perspective. Some green solutions are only useful as quick fixes, whereas other, more complex solutions requiring upfront investment will eliminate energy issues and emerging business risks. A holistic assessment thus has the advantage of finding the ideal mix of solutions with an optimum return on investment.

Perhaps the primary difficulty for CIOs is where to begin. Selecting solutions, setting priorities and determining the level of accuracy of the assessment are all nontrivial tasks to perform in-house, and calling in consultants has its own problems. For instance, consulting offers based on significant data gathering and analysis without the necessary tool support lead to high costs. Furthermore, it is questionable whether such offers are truly objective or are influenced by the consultants' partners.

In response to these problems, the 'Going Green Impact Tool' was developed to reveal existing issues, to provide a quick assessment within dynamic scenario calculations, and to provide

first recommendations to executives. The tool is particularly intended to address energy-related issues from an economic point of view.

On the one hand, it allows the important holistic assessment to be made in technical and economic terms. On the other hand, it supports the process of finding the right green solutions and of prioritizing their realization correctly. The energy-related issues of data centres are assessed, and the impact of green solutions on energy efficiency and the Total Cost of Ownership (TCO) is quantified. The green solutions currently included in the tool's calculations are virtualization, IT equipment refresh, decommissioning of unproductive IT equipment, power management, direct liquid cooling, free cooling, and the reuse of waste heat; and the list is growing constantly.

The key differentiator of the 'Going Green Impact Tool' is the ability to compare a variety of potential energy-efficient solutions with business as usual. To ensure that the most important business risk factors are taken into account, it is possible to simulate IT equipment growth, the increase of electricity prices, a CO<sub>2</sub> tax, data centre power supply limitations and cooling system limitations.

Finally, having decided which energy efficient solutions will be realized and when, the user can run a financial analysis of the green project to deter-

mine the overall cost. This analysis provides information on the return on investment, cash flow, net present value and payback period.

As the tool was developed to support executives in developing strategies for green data centres, the underlying principle is the Pareto principle, also known as the 80-20 rule. This avoids excessive complexity, ensures that the important holistic view is applied and provides results within days rather than weeks or months.

The 'Going Green Impact Tool' provides the right support for mastering energy-related issues in data centres. It ensures the necessary holistic view and includes economic aspects through a TCO analysis and business case. Furthermore it provides a solid foundation to maintain business continuity, to prevent being trapped by new environmental regulations, and to ensure acceptable operating costs in the long term. While data centres will soon face many budgetary and energy-related challenges, now is the right time to start dealing with these challenges by using the 'Going Green Impact Tool'.

**Please contact:**

Hannes Engelstaedter  
IBM Deutschland, Germany  
Tel: +49 175 4361 777  
E-mail: engelst@de.ibm.com

## The Norwegian Green IT Project Focuses on Green Data Centres and Video Conferencing

by Benedicte Fasmer Waaler

*In September 2007, fourteen members of the trade organization ICT Norway joined forces in a project named 'Green IT'. The goal of this project, which has grown to include 35 members, is to raise awareness of the link between climate change and the use of ICT.*

The project is not simply a buzzword that aims to market energy-saving devices. We see IT as a source of CO<sub>2</sub> pollution, but also as an opportunity to make large gains. We believe that we must take responsibility for the problems we create if we wish to credibly claim to be 'part of the solution'.

We strongly advise our members to certify themselves, either through ISO 14001 or as Norwegian 'Eco-beacons' (a Norwegian method for environmental certification of businesses with less than 300 employees). We work closely with the authorities responsible for 'green procurement'. We aim to

inform our customers of best practice in procurement, use and end-of-life. We work closely with our Danish and Swedish sister organizations to spread best practice across the borders, as well as with Elretur, a very effective recycling and reuse program for ICT equipment.



*Installation of a floating wind turbine in Norway. The country's goal is to produce and export more renewable energy.*

Our project has chosen to focus on best practice in the use of ICT, since both European and Norwegian authorities have documented the potential for ICT solutions to reduce CO<sub>2</sub> emissions by 15 percent (see link below). We see many ways in which ICT can make a significant contribution to European CO<sub>2</sub> levels, such as smart Grids, smart buildings and smart transportation. In addition to these three sectors, which are ripe for the use of smart ICT, we see two areas in which the Norwegian use of ICT can make a difference to CO<sub>2</sub> levels in Norway and Europe: video conferencing to reduce travel, and green data centres.

#### Norway: Clean Electricity and Long Distances

Norway's electricity is 99 percent hydroelectric and our goal is to produce and export more renewable energy. The country's vast coastline and sparse population mean that travel and transportation – which use fossil fuels – account for a huge proportion of the country's CO<sub>2</sub> accounting.

The smart use of ICT to replace and reduce travel and transportation will help Norway meet its Kyoto goals. But it also important because we can set a good example and inspire others to use the technology in the same way.

The Norwegian governmental agency NAV, for example, has made extensive

use of video conferencing. Its experiences of the potential gains as well as what is necessary to reap these gains, are valuable – not only to other governmental agencies, but to other potential users. The Green IT project believes that the large public sector in Norway can and should reduce use of air travel by as much as 20 percent.

Another excellent example of Norwegian use of video conferencing is telemedicine in the north of Norway, where doctors use the new technology to meet patients virtually rather than physically. Researchers in Tromsø estimate that the equivalent of eight and a half planes full of Norwegian patients fly each day to doctors' appointments (planes used in the north are generally small with only a few seats). An estimated 80 percent of these appointments are planned check-ups for chronically ill patients, many of whom could easily replace their plane ride with a virtual meeting.

#### Green Data Centres

Norway has, as previously stated, an abundance of stable, 'clean' electricity from 160 hydroelectric power plants. Norway is economically, geologically and politically stable and the broadband capacity within and out of Norway is good. We thereby fulfill many of the criteria used by large international companies in deciding where to locate their modern 'cloud' data centres.

Data centres need stable electricity, and alternative power sources such as wind and solar will not be stable enough in the foreseeable future. Norway also has ambitions to produce and export even more renewable energy. As of today, however, the power grids are not sturdy enough to enable us to transport more power, and several areas have had to reduce their production of hydroelectric power because it was difficult to transport it out of the region. Moreover, there is always a loss of at least 7 % in the grid.

Instead, we propose to add value to the clean energy by transforming it into bits and bytes. The EU used an estimated 34 Twh of electricity in their data centres in 2007. We believe that moving some of this activity to Norway, where the energy is green, could benefit the climate.

#### Link:

[http://ec.europa.eu/information\\_societ/activities/sustainable\\_growth/docs/com\\_2009\\_111/com2009-111-en.pdf](http://ec.europa.eu/information_societ/activities/sustainable_growth/docs/com_2009_111/com2009-111-en.pdf)

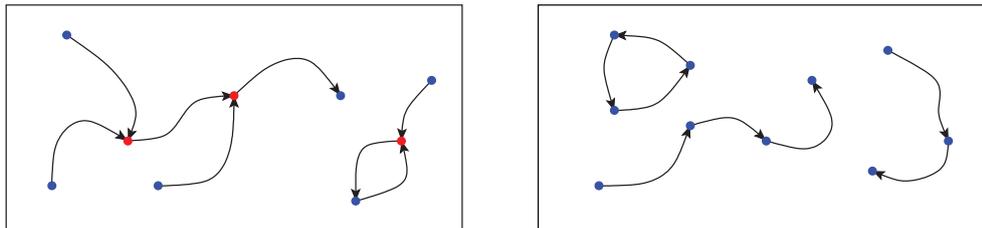
#### Please contact:

Benedicte Fasmer Waaler  
Project Manager, ICT Norway  
Tel: + 47 45 00 21 06  
E-mail: [bw@ikt-norge.no](mailto:bw@ikt-norge.no)

# MicroPower: Towards Low-Power Microprocessors with Reversible Computing

by Holger Bock Axelsen, Robert Glück, Alexis De Vos and Michael Kirkedal Thomsen

*Physics tells us that at the microscopic level the evolution of a (micro-) state is reversible, ie deterministic both forward and backward in time. In contrast, our best models of computation are usually not reversible at the microscopic level, and this carries over to actual implementations in computers. As a consequence of basic thermodynamics, this irreversibility directly contributes to heat dissipation, and therefore power consumption. However, there is nothing inherently irreversible about computation, and using reversible computation models could therefore lead to lowered power consumption. In the new MicroPower project, the Department of Computer Science at the University of Copenhagen is collaborating with the University of Ghent and the hearing-aid company Oticon, to advance the theory and practice of reversible computing at the language, logic and circuit level.*



*Figure 1: Irreversible and reversible computation paths. Red states show where the computations are irreversible.*

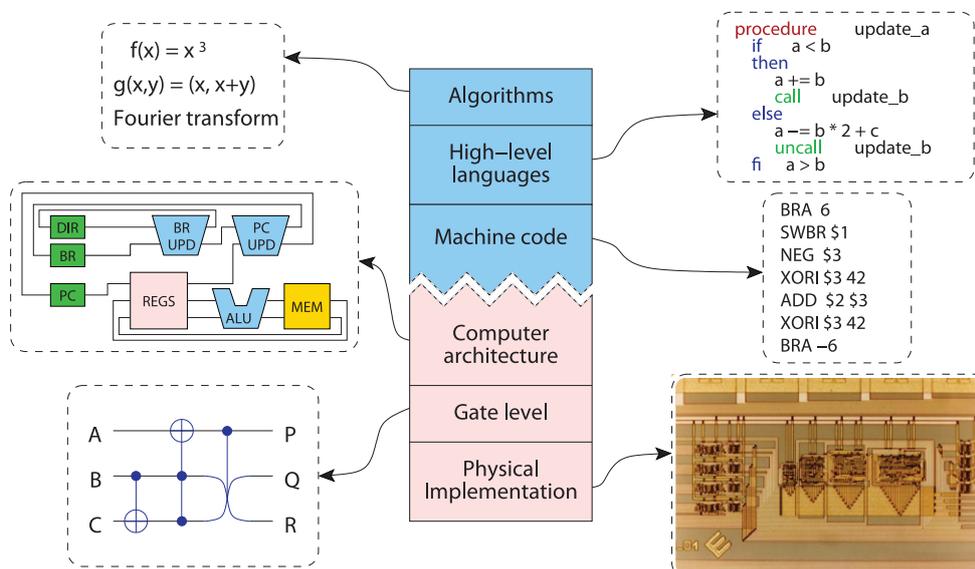
The fundamental assumption about theoretical computation models (eg Turing machines, random access machines) is that they fundamentally reflect how the computations we make take place in nature, be it on paper or in a computer. However, our best physical understanding of nature reveals a striking disparity between computation models and physics models. While physical models of nature are reversible at the microscopic level, our computational models are not. In computing, we usually cannot determine a unique predecessor to any given state: the information to do so has

been lost in the computation process (see Figure 1).

When we build a computer based on a fundamentally irreversible model (eg using irreversible logic gates such as the ubiquitous NAND-gate) this information loss carries over into the implementation (the physical layout of the processor). Thermodynamics tells us that such irreversible machines necessarily dissipate heat (and consume power) proportional to the information erased. While the lower limit on this heat dissipation is tiny (measured in

zepto-Joules,  $10^{-21}$  Joules, per erased bit at room temperature) the actual dissipation is usually much higher, and proportional to the signal energy of the erased information. In fact, this is now a central problem of modern microprocessor design, and such power issues have effectively prevented clock speeds from rising in the last several years.

However, there is nothing about computation that actually requires irreversibility. Basic theoretical results show that any computation can be performed both reversibly and irreversibly;



*Figure 2: A fully reversible computing system must be reversible at every layer from program to circuit level.*

if we build a reversible computing device however, it does not need to dissipate energy due to (irreversible) information loss, because nowhere in the computational process is any information erased. Of course, in practice there are many other factors that contribute to power dissipation, so we do not actually expect any reversible computing system to be dissipation-free. The hope is simply to reduce (rather than eliminate) power consumption, by using reversible computing principles.

Historically, the incentive to develop reversible computing systems has been limited, since it is really only in the last decade that power issues have become such a dominant factor. As a consequence, reversible computing is seriously underdeveloped at this point. This gap in our knowledge of computing has become much more apparent in recent years, because reversibility has turned up in some completely different areas of computer science with advantageous properties unrelated to the original issues

of power. For example, reversibility is a useful property in static timing analysis for programs, reliability analysis for embedded systems, quantum computing, and bidirectional model transformations in connection with the view-update problem for databases.

At the Department of Computer Science at the University of Copenhagen (DIKU), we study reversible computing models from the perspective of programming languages and logic design. In the new MicroPower project supported by the Danish Council for Strategic Research, DIKU has set up a collaboration with the Electronics and Information Systems Department at Ghent University (ELIS, a leading centre for reversible microelectronics) and the international hearing-aid company Oticon. The purpose of this basic research project, which will run from 2009 to 2012, is to advance and develop the theory and practice of reversible computing at the programming language, logic and circuit-design level,

taking us one step closer to an actual, reversible microprocessor.

A fundamental challenge in this setting is that every abstraction layer must be reversible (see Figure 2). We cannot expect to reap the full benefits of reversibility if we run, say, a reversible program on an irreversible architecture (even though significant benefits are still possible in this case; eg automatic program inversion, simple debugging). Thus, understanding how the different layers of reversible computing systems interact is a central goal of our research.

**Links:**

DIKU: <http://www.diku.dk>

ELIS: <http://www.elis.ugent.be/en>

Oticon: <http://www.oticon.com>

**Please contact:**

Robert Glück

Dept. of Computer Science, University of Copenhagen, Denmark

Tel: +45 35321400

E-mail: [glueck@acm.org](mailto:glueck@acm.org)

## Boosting Research in Electronics Enabling Efficient Energy Usage

by Erich Prem

*The first results of the E4U initiative to develop a new 'electronics for energy efficiency' research agenda are now available.*

Today, 40% of energy consumed is electrical energy, and this share is forecast to grow to 60% by 2040. Much of this is wasted, and if Europe is to reach its ambitious goals for the reduction of greenhouse gases, it is essential that electrical energy be used more efficiently. This is all the more necessary because of the need to remain competitive internationally. If Europe wishes to reap the enormous potential of new technologies for energy efficiency, it must not only invest in its excellent research and technology base but also improve its strategies for research in this area.

These are the aims of the initiative E4U ('Electronics Enabling Efficient Energy Usage') which is devising a strategic action plan for power electronics research in Europe. Recent advances in power electronics and information tech-

nology make them crucial to harvesting the enormous potential to save electrical energy in households, transportation, industry and consumer products.

Power Electronics is a cross-functional technology covering the high gigawatt (GW) power in energy transmission lines down to very low milliwatt (mW) power needed to operate a mobile phone. It is responsible for the reliability and stability of the whole power supply infrastructure in Europe from the sources, the transmission and distribution, up to the broad variety of applications in industry, transportation systems and the home. Power electronics is the key to precisely controlling the flow of electrical energy from the source to the load according to the requirements of the load. The E4U initiative sets the focus on the huge energy savings

enabled by power electronics in four areas of application:

- Buildings account for more than 40% of energy use in developed countries. Applying existing energy-efficient technology it is possible to achieve energy savings of between 40% (for heating, ventilation and air conditioning) and 80% (for lighting, by combining efficient sources with intelligent control).
- Power supplies process the energy required to operate almost all electronic equipment. According to the International Energy Agency, residential appliances account for over 30% of electricity consumption in most countries and represent one of the fastest growing energy loads. It is estimated that at least one-third of this could be saved cost-effectively by 2030.

- In the industrial manufacturing area, electric drives account for around 65% of electricity consumption. Currently, the vast majority of these motors do not have electronic controls. By converting all such simple electric motors to variable speed, it is possible to cut power consumption by almost half.
- Power electronics will also play a key role in future smart electricity networks. The smart grid is a combination of information, communications and power electronics that improves all the elements of the electricity chain from generation and transmission to distribution and consumption, in order to improve the efficiency, reliability and security of supply and cost.

E4U will foster world leadership in electronically enabled energy efficiency in the EU. Based on an analysis of the European research scene in this field and following discussions with European experts and the industry, E4U has created a strategic roadmap. This roadmap starts from specific European strengths such as the electronics industry and our high-quality research groups. It also acknowledges the improvements to be made in software

tools, in bringing device and component costs further down, and in improving the use of wide bandgap semiconductor materials.

It will be vital for Europe's success in this field to foster a more coherent research landscape. Today, with very few exceptions, power electronic topics are spurious in public research programmes. Europe needs many more explicit actions targeting electronics research for energy efficiency. It also needs to focus on key industrial and technical challenges such as reducing the cost of components and systems, improving reliability, fostering modularity and standardization, and pushing efficiency even further. It is also necessary to dramatically improve the visibility of this kind of research through demonstrations and coordinated large-scale initiatives. This will not only help to overcome the current fragmentation of the research scene, but will also attract more young researchers to a research field that is vital for Europe's future.

The E4U initiative is coordinated by eutema Technology Management. Further partners are the European Centre for Power Electronics, the

Universidad Politécnica de Madrid and the Tyndall Institute in Cork. E4U receives funding from the European Commission's ICT programme of FP7.

**Link:**  
<http://www.e4efficiency.eu>

**Please contact:**  
 Erich Prem  
 eutema Technology Management  
 GmbH, Austria  
 Tel: +43 1 5245316  
 E-mail: [prem@eutema.com](mailto:prem@eutema.com)

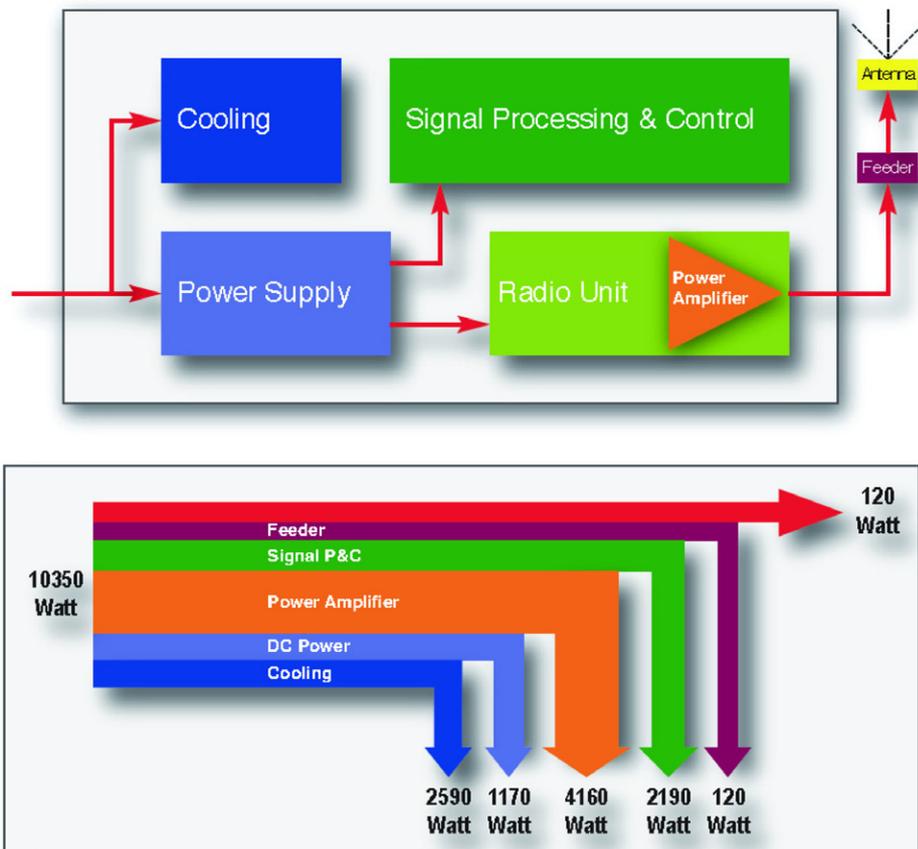


Figure 1: Typical power losses in a radio base station.

# Using Waste Heat from Data Centres to Minimize Carbon Dioxide Emission

by Gerhard Ingmar Meijer, Thomas Brunschwiler, Stephan Paredes, and Bruno Michel

*'Zero-emission' data centres require 40% less energy than existing data centres, and by using their waste heat for purposes such as space heating their effective carbon dioxide emissions can be reduced by 85%. Payback for heat and improvements in efficiency can cut energy costs by a factor of two, with a return on investment in under two years.*

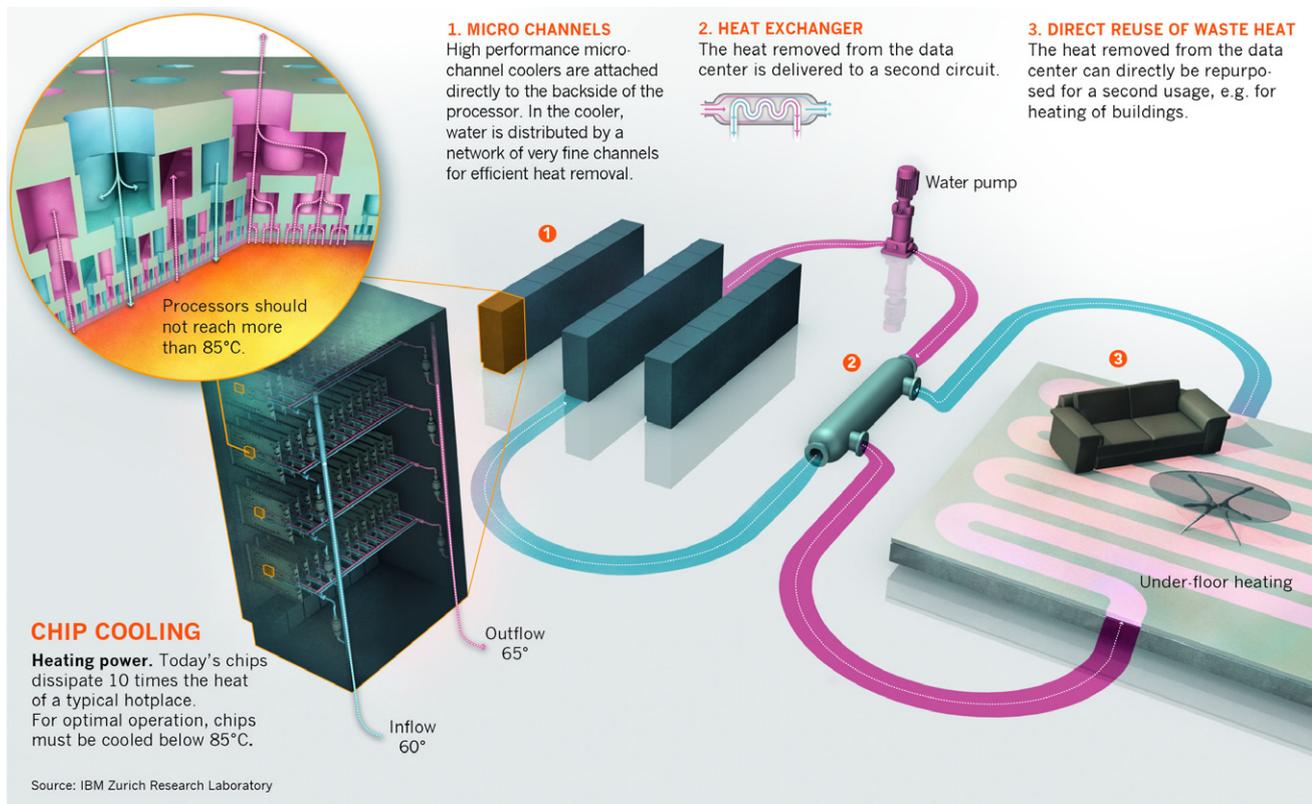
The IT industry accounts for 2% of global carbon emissions, as much as is released by air traffic. This figure doubled in the past five years, and the worldwide electricity consumption of data centres now equals the energy produced by fourteen large (1 GW) power plants. Large (cloud) data centres consume up to 200 MW of electrical power, with all the excess heat produced being dissipated into the environment. At the same time, our society still uses high-value primary energy sources, such as gas and oil, for space heating. Our research group has developed an innovative concept that brings together the heat producer and the heat consumer to make waste heat productive: an attractive prospect from both an economic and an ecological perspective.

Up to 50% percent of the energy consumption and carbon footprint of an air-cooled data centre is caused not by computing but by powering the cooling systems needed to keep the microelectronic components from overheating. As energy efficiency is arguably the primary challenge faced by humanity in the 21st century, we can no longer afford to design computer systems based solely on the criteria of computational performance. The new target must be high performance and low net power consumption (and, concomitantly, low net carbon footprint). This requires high-performance liquid cooling.

Water is an excellent coolant which is able to capture heat about 4,000 times

more efficiently than air. If high-performance liquid coolers are used, water with temperatures up to about 60°C would keep the processors at operating temperatures well below the maximally allowed 85°C. This eliminates the need for today's energy-hungry chillers in the data centre. Moreover, the high-grade heat at the output can be reused, for example, for space heating.

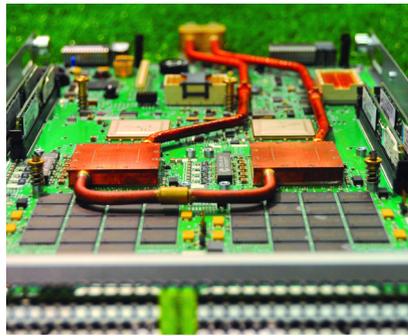
We have built a small-scale prototype system at IBM as a testbed for a new water-cooled supercomputer that will be delivered to the Swiss Federal Institute of Technology Zurich (ETH) later this year. With its innovative water-cooling system, the energy consumption of this new supercomputer is expected to be reduced by 40% and its



**Figure 1: Schematic concept of the zero-emission data centre. Heat is collected from the individual microelectronic components and transferred via a heat exchanger to a district heating system to be used for space heating.**

carbon footprint by 85% compared to systems using today's air-cooling technology. The low carbon footprint is possible because the excess heat will be used to heat the university buildings (Figure 1). (Note: elimination of the carbon emission caused by combustion processes for space heating can, according to rules defined in the Kyoto Protocol, be credited against the carbon emission of the data centre).

The water-cooled supercomputer will consist of 33 IBM BladeCenter® QS22 (6 DP TFlop/s) and 9 IBM BladeCenter® HS22 and will have an efficiency of more than 500 MFlop/s per Watt. The blades will be equipped with high-performance micro-channel liquid coolers, and can easily be connected to and disconnected from the system (see Figure 2). The fluid loops of the individual blades link to the larger network of the server rack, which in turn is connected to the main water transportation network. The cooling system is a closed circuit: The cooling water is heated by



*Figure 2: Prototype of water-cooled blade with two high-performance micro-channel liquid coolers that remove heat from the processors.*

the microelectronic components and circulated through a passive heat exchanger. In the heat exchanger, the excess heat is removed and fed directly into the heating system of the ETH.

This project is a significant step towards energy-aware, emission-free computing and data centres. With this new super-

computer system, we intend to demonstrate that using high-performance computing to address challenges in science need not have an adverse effect on energy consumption and the environment.

IBM and BladeCenter are trademarks of International Business Machines Corporation in the United States, other countries, or both. Other company, product, or service names may be trademarks or service marks of others.

**Links:**

<http://www.research.ibm.com/journal/rd/533/brunschwiler.pdf>

<http://www-03.ibm.com/press/us/en/pressrelease/27816.wss>

**Please contact:**

Gerhard Ingmar Meijer  
IBM Research GmbH, Zurich Research Laboratory, Switzerland  
E-mail: [inm@zurich.ibm.com](mailto:inm@zurich.ibm.com)

## Nautilus - A Testbed for Green Scientific Computing

by Bartosz Borucki, Maciej Cytowski and Maciej Remiszewski

*The Nautilus supercomputer is a development system for hybrid computing. It is the result of a deep technology collaboration between IBM and the Interdisciplinary Centre for Mathematical and Computational Modelling (ICM) at the University of Warsaw, and is looking at the future of adaptive computing and high-performance computing systems. Nautilus is a testbed for new programming frameworks that will help harness the power and efficiency of next-generation processors and accelerators for a wide variety of scientific applications. Approaching the first anniversary of its initial installation, the system has already made several significant achievements.*

Though the two-rack cluster was conceived as a small prototype system, the sheer compute power of the PowerXCell8i CPUs meant it was listed in the November 2008 edition of the Top500 list of the world's fastest supercomputers. In fact, at one point it ranked as high as #220, with a LINPACK result of over 18 TFlops. It now stands at #421. Even more impressive is the power consumption of the system relative to its performance. With 536 MFlops/Watt, it has set a new world record in supercomputer efficiency and was officially ranked #1 on the Green500 list. This record still holds, with none of the new systems in the

June 2009 edition of the top500 list able to improve on it.

Nautilus was developed, installed and tuned under close collaboration with IBM Development. The project involved specialists from Poland, Germany and the US working both on-site and remotely on the machine installed at an IBM data centre in Warsaw. The project schedule for meeting the Top500 submission deadlines was very tight and at that point, several parts of the solution were still not officially supported while others were attempted for the first time. One example was the cluster network. The

system used a fully non-blocking double data rate InfiniBand fabric (DDR IB) directly interconnecting all QS22 blades. Throughout the installation and tuning process, new drivers and patches had to be developed to achieve the best performance and stability from the system. These software components have eventually made it to the official software stack, which was released at a later stage together with official support for DDR IB adapters for the QS22 blades.

Another example, which demonstrates the unique nature of this system, is the CPU clock speed. After successfully

completing the LINPACK runs at the standard frequency of 3.2 GHz, the system achieved 530 MFlops/Watt, breaking the previous record of 488 MFlops/Watt as well as the magical 500 MFlops/Watt barrier for the first time in history. Thanks to the strategic relationship between ICM and IBM, the companies have decided to use this prototype system to demonstrate the capability of the PowerXCell8i CPUs to operate at 4 GHz. This involved changing the blade firmware and increasing the frequency of several components, including not only the CPUs but also memory, which has been clocked at 1 GHz. This could only be done under the close supervision of IBM Development engineers who were closely monitoring the system hardware. The procedure turned out to be a great success: the system delivered stable LINPACK results and was able to further improve its power efficiency to 536 MFlops/Watt, setting a new world record a few days before the final submission deadline.

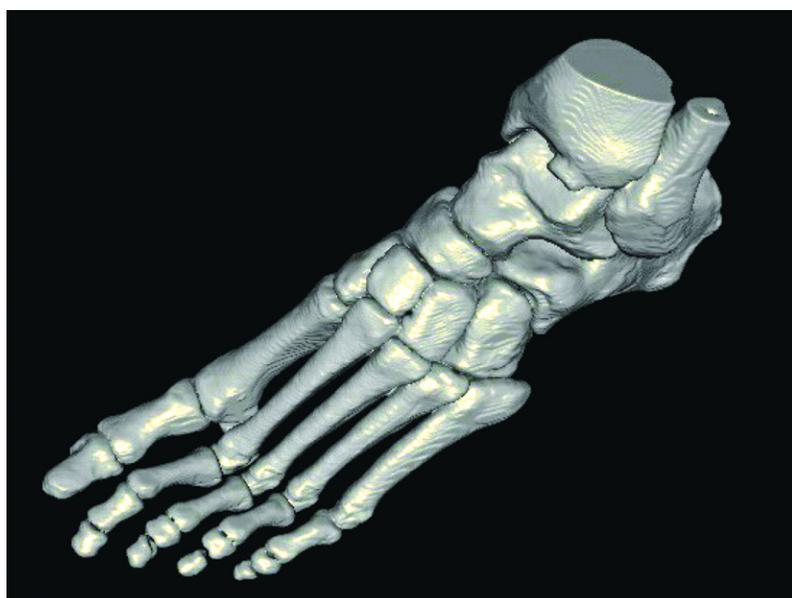
The Nautilus system is dedicated to the scientific projects of ICM's high-performance computing centre users. The first project began over two years ago. A periodicity searching application used by scientists from the Astronomical Observatory of University of Warsaw in the OGLE project (Optical Gravitational Lensing Experiment) was ported to the Cell architecture with great success. It achieved a greater than 9x speedup compared to the initial implementation. This enabled the whole computation to be finished in less than two weeks rather



**Figure 1: The Nautilus system.**

than a few months. The lessons we learnt from porting and optimizing the scientific application for the OGLE project enabled us to select other classes of scientific computing code that could benefit from the Nautilus design. These classes range from bioinformatics, molecular dynamics and epidemiology to scientific visualization, number theory and optimal control problems, and we have been able to achieve similar performance results in those disciplines. The Nautilus system is also available for computer science students. Their work is additionally supported on the basis of the IBM Faculty Award that ICM received last year.

One of the very promising applications of the Nautilus supercomputer is the visualization system developed in deep



**Figure 2: One of the high-resolution images generated by VisNow and iRT.**

collaboration with IBM. Medical images are first analysed and processed by ICM's visualization system called VisNow, which produces high-resolution 3D models. Those models are later rendered on part of the Nautilus system using an interactive ray-tracing tool called iRT, designed and developed by IBM Research Laboratory in Austin, USA. The resulting framework enables researchers and medical doctors to visualize and handle medical data at unprecedented levels of detail and image quality.

Short descriptions of all these projects are available online (see link below).

The collaboration between IBM and ICM goes back several years. Initial discussions around hybrid computing started in late 2006 with the introduction of the Cell Broadband Engine processor. As both companies were interested in forming a strategic partnership, the discussions quickly evolved into a continuous collaboration involving several specialists and spanning multiple departments on both sides. In 2008, a formal collaboration agreement was signed establishing the Joint Cell Competence Centre as the first teaming initiative. Several other collaborative activities based on IBM Deep Computing technology are emerging, as the partnership between the two companies continues to deliver value to the scientific community.

**Links:**

- ICM: <http://www.icm.edu.pl>
- ICM & IBM Joint Cell Competence Centre: <http://cell.icm.edu.pl>
- Nautilus projects: <http://cell.icm.edu.pl/index.php/Projects>
- VisNow visualization system: <http://visnow.icm.edu.pl>

**Please contact:**

Bartosz Borucki, Maciej Cytowski  
 Interdisciplinary Centre for  
 Mathematical and Computational  
 Modelling (ICM),  
 University of Warsaw, Poland  
 E-mail: [b.borucki@icm.edu.pl](mailto:b.borucki@icm.edu.pl),  
[m.cytowski@icm.edu.pl](mailto:m.cytowski@icm.edu.pl)

Maciej Remiszewski  
 Deep Computing Leader, Central and  
 Eastern Europe (CEE)  
 IBM Poland  
 E-mail: [maciej.remiszewski@pl.ibm.com](mailto:maciej.remiszewski@pl.ibm.com)

# IANOS: How to Do More Science with Less Energy

by Vincent Keller and Wolfgang Ziegler

**Intelligent ApplicationN-Oriented Scheduling (IANOS) is a framework built atop a Grid middleware that uses resources in an energy-efficient manner. IANOS selects appropriate resources for a given application, chooses the most energy-efficient one, and turns off the unused parts of the selected resource if not needed.**

You are a computational scientist using high-performance computing (HPC) resources. Maybe you are an administrator or a manager of an HPC centre providing resources to multiple communities of users working on different scientific areas, or you are simply interested in how to efficiently use a Grid of HPC resources and applications. Do you think it is possible to do more science while using the resources in a more energy-efficient way? Is it possible to predict a better set of resources based on the needs of your users' applications? Can a system give you hints and tips to improve the implementation of your applications? If your answer is "no" to these questions, take five minutes. After reading this article your ideas will be quite different, because these are the goals of Intelligent ApplicationN-Oriented Scheduling (IANOS).

In 2009, HPC resources worldwide are consuming approximately the energy produced by fifteen 2GW power plants. Is all that energy used in an efficient manner? If it were possible to talk about a metric 'science per watt', its value today would surely be far less than twenty-five years ago. There are many reasons for this. For instance, high-end resource consumption today is an order of magnitude greater than what it was

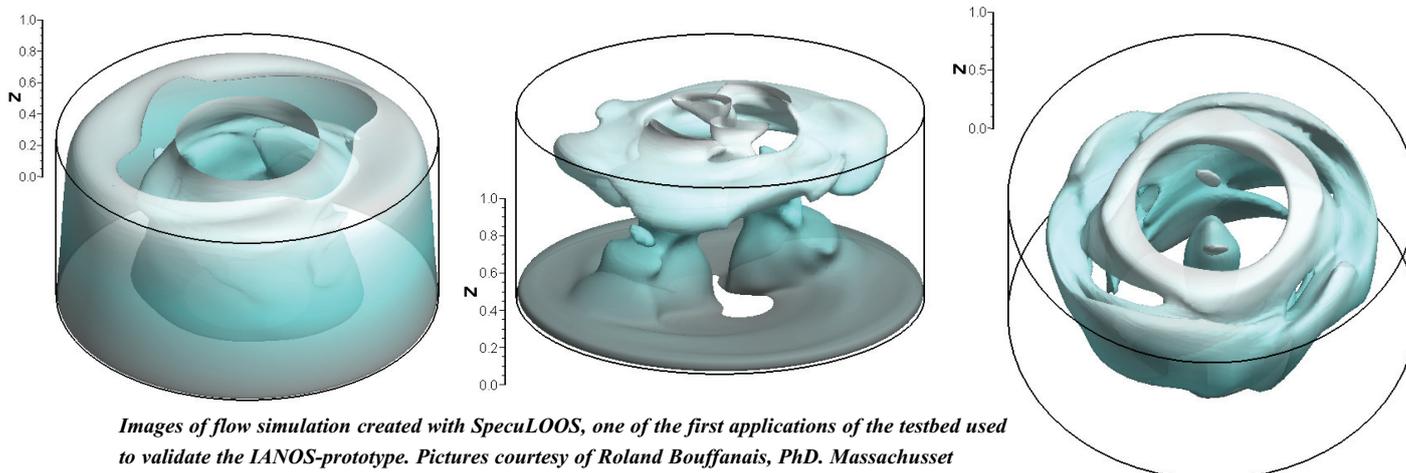
two decades earlier: 1-5 MW is the common energy consumption for a Top10 system, compared with the 200-300 KW needed by a Cray-2 twenty years ago. In addition, applications are now less efficient: today, an efficiency of 50% is considered good, whereas in 1985 codes performing at over 90% efficiency were common.

Energy-hungry resources are thus being used in a non-efficient manner, effectively meaning that less and less computing power is at the disposal of scientists. The final consequence is that the resources are over-booked.

IANOS is a framework built atop a Grid middleware (UNICORE or Globus) but agnostic to that middleware. It consists of (i) an information system that stores information relating to the applications and resources; (ii) a Grid-level resource broker that decides which resources are the most appropriate for a given application under a user's request for quality of service (QoS) at a given time; (iii) a meta-scheduler that interacts with the underlying Grid middleware and collects information on the status of the resources; and (iv) a monitoring system that records the behaviour of the applications during their execution.

The first original concept of IANOS is that the applications are parameterized, the needs of the applications are characterized, and the resources are also parameterized so that the resource broker knows what each resource provides (computing power, network performance or memory bandwidth for each node, for instance). These parameterizations are used to predict the execution time on a given resource of a given instance under its input data (such as the size of the problem, a previous stage of a simulation or a given accuracy for certain numerical simulation).

The brokering algorithm is the second original concept of IANOS: it is the matching function between what the application requires and what the resource provides under a user's request for QoS. It is based on a cost function. All the costs of an application's submission are computed: execution cost, waiting-time cost, licence cost, ecological cost and data transfer cost. Note that the execution cost includes all the fixed costs of the usage of a resource within a data centre. We propose a model which includes: investment, personnel, maintenance fees, interest to be paid to the bank, infrastructure, management, overhead, insurance fees and margin costs. This information is stored



*Images of flow simulation created with SpecuLOOS, one of the first applications of the testbed used to validate the IANOS-prototype. Pictures courtesy of Roland Bouffanais, PhD. Massachusetts Institute of Technology (MIT), MA, USA.*

in the information system and entered once by the system administrator through a Web interface. The QoS specified by the user can be: "I want my results as soon as possible regardless of the cost", or "I want my results for the smallest amount of money, regardless of the time", or a mix of both. At submission time, the status of all the resources is gathered by the meta-scheduler. The overall cost is then computed by a minimization process for all the resources, and the job is assigned to the best and most energy-efficient resource. The Grid of resources is thus better used and the metric 'science per watt' increases. The process is completely automatic: the user need only choose the application, select the QoS and hit the 'submit' button.

With İANOS therefore, energy efficiency is achieved through three mechanisms based on different stages of running an application. First, İANOS selects the most appropriate resources

based on the needs of the applications, ie from the available resources it selects the set that will execute the application with the highest efficiency and the lowest execution time. Second, İANOS chooses and schedules the application on the most energy-efficient resource (from the previously selected set) according to the QoS specified by the user. Third, İANOS goes even further: knowing in advance what the application needs, it is possible to modify the target architecture, for instance by switching off a processor to increase energy efficiency without reducing performance. As an additional benefit, by comparing the actual runtime of the application with a prediction based on the theoretical behaviour of the application, the user can detect problems in the implementation of the application and pinpoint flaws in the code.

In the context of the CoreGRID Network of Excellence and the Swiss

ISS project, a prototype of İANOS was developed, implemented and in mid-2008 tested on an international testbed across Switzerland and Germany. We plan to develop and deploy the İANOS services for the European e-Infrastructure through a new European project.

**Link:**

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

**Please contact:**

Vincent Keller  
Fraunhofer SCAI, Germany  
Tel: +49 2241 14 2280  
E-mail: [Vincent.Keller@scai-extern.fraunhofer.de](mailto:Vincent.Keller@scai-extern.fraunhofer.de)

Wolfgang Ziegler  
Fraunhofer SCAI, Germany  
Tel: +49 2241 14 2248  
E-mail:  
[Wolfgang.Ziegler@scai.fraunhofer.de](mailto:Wolfgang.Ziegler@scai.fraunhofer.de)

## Creating Power-Aware Middleware for Energy-Efficient Data Centres

by Eduard Ayguadé and Jordi Torres

*Self-managed middleware should be able to manage resources transparently and cost-effectively, while hiding the underlying complexity from users. Our group at the Barcelona Supercomputing Centre (BSC) and Technical University of Catalonia (UPC) has strengths in a diverse set of research areas, and through cross-disciplinary studies is building middleware that has the additional crucial feature of intelligent power management.*

Because of the escalating price of power, energy-related costs have become a major economic factor for IT infrastructure and its host data centres. In addition to improving energy efficiency, companies are facing increasing pressure to reduce their carbon footprint due to EU regulations and campaigns demanding greener businesses.

The research community is therefore being challenged to rethink data centre strategies, adding energy efficiency to a list of critical operating parameters that already includes service availability, reliability and performance. While a large variety of power-saving proposals has been presented in the literature, workload consolidation and powering off spare servers are obvious and effective

ways to save power. Server consolidation involves combining workloads from separate machines and different applications into a smaller number of systems. This is done using virtualization technology that allows the consolidation of applications, multiplexing them onto physical resources while supporting isolation from other applications sharing the same physical resources. This approach solves some interesting challenges: less hardware is required, less electricity is needed for server power and cooling, and less physical space is required.

The success of the consolidation strategy requires that the underlying complexity be hidden from users, and this is done by building self-managed

middleware that can manage the resources transparently and in the most cost-effective way. To build this middleware with more intelligent power management will require cross-disciplinary studies over a diverse set of research areas. It is a complex end-to-end problem, requiring an intricate coordination of hardware, operating systems, virtual machines, middleware and applications.

The team at the Barcelona Supercomputing Center (BSC) is working on these topics (see link below). Our research demonstrates how consolidation with energy efficiency goals still has a long way to go beyond the use of virtualization. We have identified new opportunities to improve the

energy efficiency of systems, reducing the resources required without negatively affecting performance or user satisfaction. For instance, request discrimination is introduced to identify and reject those requests that consume system resources but have no value for an application (eg requests coming from content-stealing Web crawlers). Memory compression is another example, converting CPU power into extra memory capacity to overcome system underutilization scenarios caused by memory constraints. Our results show that considering these techniques during placement decisions can boost the energy savings in a data centre.

are addressing the problem of predicting and managing the performance of MapReduce applications, trying to meet performance goals while considering several high-level objectives such as energy saving, and without wasting physical resources. Obviously, we are also looking at multi-core processors with better performance and the energy efficiency necessary to meet these demands in years to come.

BSC and the Technical University of Catalonia (UPC) are contributing to the research community with the EMOTIVE (Elastic Management of Tasks in Virtualized Environments) framework, which provides an elastic, fully customized, virtual environment in which

running in third-party providers such as Amazon EC2 to be managed in a federated environment. These functionalities of the EMOTIVE framework ease the development of new resource management proposals, thus contributing to the innovation in this research area.

The research community must continue to find ways to ensure that performance improvements are accompanied by corresponding improvements in energy efficiency. The next generation of computing systems must achieve significantly lower power needs, higher performance/watt ratio, and higher dependability than ever before. This is something that can only be achieved with a holistic approach.

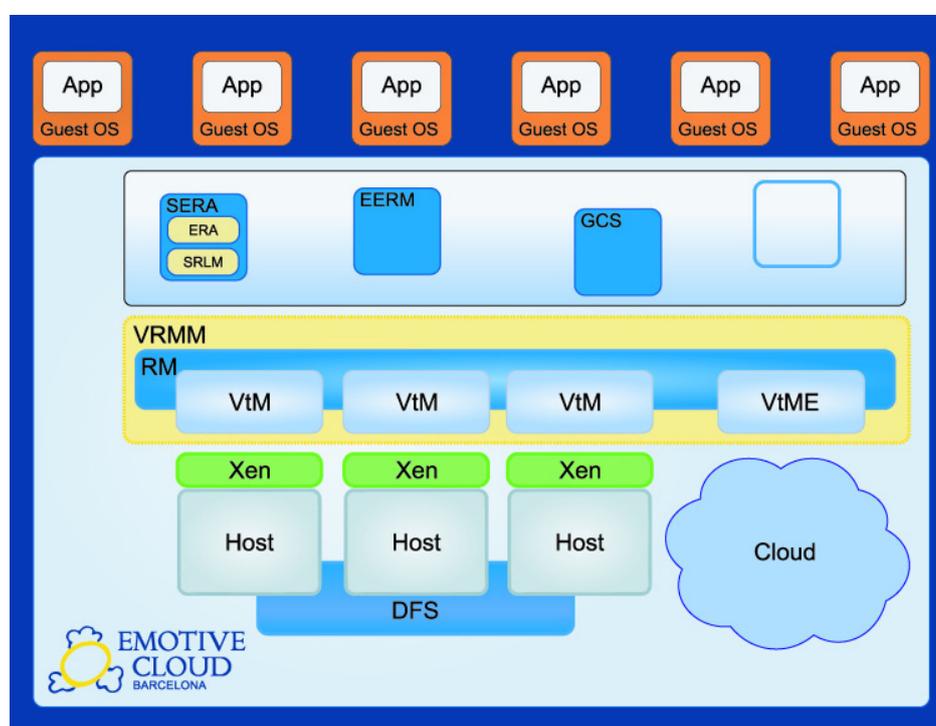


Figure 1: EMOTIVEcloud – Elastic Management of Tasks in Virtualized Environments.

Our research group has also proposed ways of rescuing resources by reducing waste. For example, middleware can hide and prevent some system failures or denial-of-service flooding attacks, thus avoiding the potential disruptions of unplanned outages and the associated loss of resources. An important component of this middleware is the predictive modelling available through self-monitoring analysis. Our current approach is applying new methods and concepts from machine learning that can not only find accurate models of and explanations for system behaviours, but also predict and estimate system states and values. Currently, we

to execute services, and which allows the development of new schedulers that take power usage into account when building the consolidation process (Figure 1). EMOTIVE abstracts a Cloud architecture using different layers and provides users with basic primitives for supporting the execution of tasks in an infrastructure. The core layer wraps each virtualized node and monitors its state, granting full control to the application of its execution environment without any risks to the underlying system or the other applications. In addition, it allows both local virtual machines (ie running in the provider's nodes) and remote virtual machines

#### Links:

<http://www.bsc.es/grid>  
<http://www.emotivecloud.net>  
<http://www.greenit-conferences.org>

#### Please contact:

Jordi Torres  
 UPC-BSC, Barcelona, Spain  
 E-mail: [torres@ac.upc.edu](mailto:torres@ac.upc.edu)  
<http://people.ac.upc.edu/torres>

# Green Building Blocks - Software Stacks for Energy-Efficient Clusters and Data Centres

by Dimitrios S. Nikolopoulos

*The Green Building Blocks (GBB) project is a joint effort between the Computer Architecture and VLSI Laboratory (CARV) of the Institute of Computer Science at the Foundation for Research and Technology – Hellas (FORTH-ICS), and the Department of Computer Science at the Virginia Polytechnic Institute and State University (CS@VT). GBB is a stacked assembly of device drivers, performance monitors, operating system and runtime modules, which interoperate to provide software capabilities for reducing the energy footprint of applications running on clusters and data centres, while sustaining performance near the maximum levels achievable with the hardware at hand.*

## GBB Architecture Layers

The architecture of GBB is shown in Figure 1. GBB provides a software backbone for fully instrumented, energy-friendly clusters. GBB targets clusters and data centres built entirely from power-scalable devices, that is, devices with multiple power states and programmable power state transitions, including cores, CPUs, DRAM and disks. The instrumentation layer of GBB uses hardware event monitors on processor, memory, networking and I/O devices, continuous AC and DC power monitors, and on-board and ambient thermal sensors. The runtime layers implement dynamic power management policies, based on performance and energy signatures of applications collected at runtime. The policies target holistic optimization of energy efficiency at the system level.

## GBB Implementation

The current GBB prototype is implemented on non-virtualized deployments of Linux clusters, and includes the Eco-meter, Eco-kernel, Eco-OpenMP and Eco-MPI modules (Figure 1).

Eco-meter is a hardware monitor that collects periodic samples of device-specific event counters, from which it builds a performance, power and thermal signature (the PPT profile) of a running application. Application signatures are partitioned into phases of computation separated by communication or synchronization events. The signatures derived by Eco-meter are formulated as polynomial models, which correlate samples of event rates and configurations of hardware resources – specifically, the allocated capacity and power mode of each resource – with performance and power consumption. Eco-meter is used by user-level runtime systems in their policy modules, to predict the performance and power consumption

of each phase in an application, in response to probes that change temporarily the underlying configuration and capacity of hardware resources.

Eco-kernel provides an API for scaling device capacities and power modes on demand. The purpose of eco-kernel is to replace application-oblivious power management policies in the operating system with application-specific, phase-aware policies controlled explicitly by the runtime.

Eco-OpenMP is an energy-efficient implementation of OpenMP. The Eco-OpenMP runtime uses interfaces to Eco-meter and Eco-kernel to implement

dynamic power consumption while sustaining and occasionally improving performance. DVFS also reduces dynamic power consumption while sustaining performance. Both are most effective during memory-intensive phases of computation. The DCT and DVFS policies in Eco-OpenMP are based on multi-linear regression models correlating performance with samples of event counters, thread count and core layout on systems with multiple multi-core processors. The combined phase-aware DCT-DVFS optimization scheme used in Eco-OpenMP reduces execution time by 13.7%, total system power consumption by 5.9%, overall energy consumption by 18.8% and energy-delay

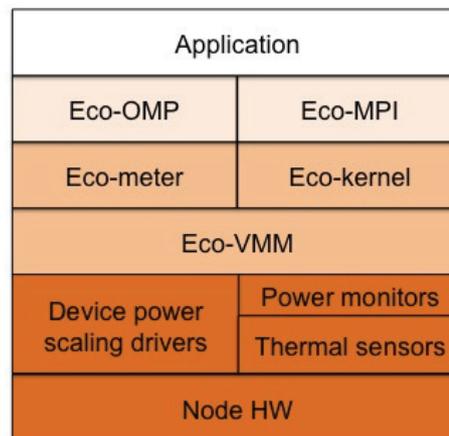


Figure 1: Green Building Blocks architecture.

optimization policies that improve energy efficiency while maintaining a hard lower performance bound. Eco-OpenMP operates simultaneously two software ‘knobs’ for controlling power efficiency, dynamic concurrency throttling (DCT) and dynamic voltage and frequency scaling (DVFS). By alleviating contention between threads for shared resources, such as memory bandwidth and cache space, DCT provides opportunities for reducing

product by 39.5% in the NAS OpenMP benchmark suite.

Eco-MPI is an energy-efficient implementation of the Message Passing Interface (MPI) communication and tasking runtime substrates. The power-efficiency optimization policy of Eco-MPI is based on a model of slack time arising during the interaction between MPI tasks in communication phases. Eco-MPI is built on top of Eco-meter and

Eco-kernel and follows the phase-sensitive optimization strategy used also on Eco-OpenMP. Applications are decomposed into phases separated by communication events. Eco-MPI estimates slack time due to communication and computation load imbalance, using a novel model which calculates the rippling effects of slack on interacting tasks, both within a node and across nodes. Eco-MPI is the first software prototype to achieve real-time power reduction on clusters of up to 256 nodes, yielding up to 14% total energy savings in the Lawrence Livermore National Laboratory (LLNL) Sequoia Benchmark suite. Eco-MPI is integrated with Eco-OpenMP to implement power-aware execution of hybrid MPI-OpenMP programs.

#### Current and Future Work

GBB is extended in four directions. The first is virtualization of the power,

thermal and performance instrumentation infrastructure, followed by the derivation of appropriate metrics that would apportion resources to applications in order to improve energy efficiency under performance constraints. The second direction is the implementation of cluster-level static and dynamic task aggregation. Static task aggregation amounts to clustering application tasks in fewer nodes than the number of nodes apportioned to applications at submission time. Dynamic task aggregation amounts to dynamic clustering of tasks after application submission and is enabled through virtual machine migration mechanisms. The third direction is the integration of multi-device scaling capabilities in GBB, in particular DRAM and disk scaling, in a unified modeling and policy framework. This research will enable GBB to target data-intensive workloads dominated by I/O

and memory traffic. The fourth direction is the development of a GBB runtime for the MapReduce programming model, targeting large-scale data processing tasks on compute clouds.

#### Links:

<http://www.ics.forth.gr/carv>  
<http://www.cs.vt.edu>  
<http://people.cs.vt.edu/~dsn/papers/PACT08.pdf>  
<http://people.cs.vt.edu/~dsn/papers/TPDS08.pdf>  
<http://people.cs.vt.edu/~dsn/papers/ICS06.pdf>

#### Please contact:

Dimitrios S. Nikolopoulos  
 University of Crete and FORTH-ICS  
 Tel: +30 2810 391657  
 E-mail: [dsn@ics.forth.gr](mailto:dsn@ics.forth.gr) |  
<http://www.ics.forth.gr/~dsn>

## Evaluating the Energy Consumption of Enterprise Storage

by Doron Chen, Ronen I. Kat and Kalman Meth

***Evaluating the energy consumption of enterprise applications is a fundamental step towards energy efficiency. The total energy cost of an application is the sum of its compute, storage and network energy consumption. We outline a method for estimating the storage part of the application energy cost.***

Energy-efficient storage relies on tools and frameworks that allow us to measure the storage energy consumption. Although such tools are becoming more prevalent for enterprise storage, they only measure the energy consumption of storage servers, not the energy consumed by application data.

In most cases, the enterprise data of different applications is stored on different logical entities (logical volumes) of the same storage server (Figure 1). Different applications have different storage usage patterns (ie workloads) and utilizations. The energy consumption of the storage server depends on the aggregation of various application workloads. This makes it difficult to proportionally divide the energy cost of the storage server between the different applications.

Researchers at the IBM Lab in Haifa, Israel have addressed this challenge by

devising a modelling framework that estimates the energy consumption of storage servers based on the underlying storage configuration and the application I/O workload. Our framework estimates the energy consumption of disk arrays and utilizes heuristics to fairly distribute the energy cost between the logical volumes, based on the application workloads. The storage server energy consumption is composed of fixed and dynamic portions. The fixed portion is independent of the workload, while the dynamic portion is directly affected by the application workload.

The framework uses a small dataset of energy consumption tables, one for each storage component, to compute the dynamic portion. The dataset describes the energy consumption relative to the number of operations performed by the components. Building the dataset is a one-time process for each type of storage server.

The framework is composed of three steps:

1. A translation methodology estimates the number of activities performed by the storage components in order to execute the application workload. An activity is a storage operation that can be directly associated with energy consumption; for example, disk head movement or data transfer.
2. An interpolation step estimates the energy consumption of the physical storage components based on the level of activity computed in Step 1 and the energy consumption dataset.
3. The energy consumption of the logical volumes is estimated based on capacity and application workloads.

The application workload is translated to values representing the quantities of primitive storage activities, such as the

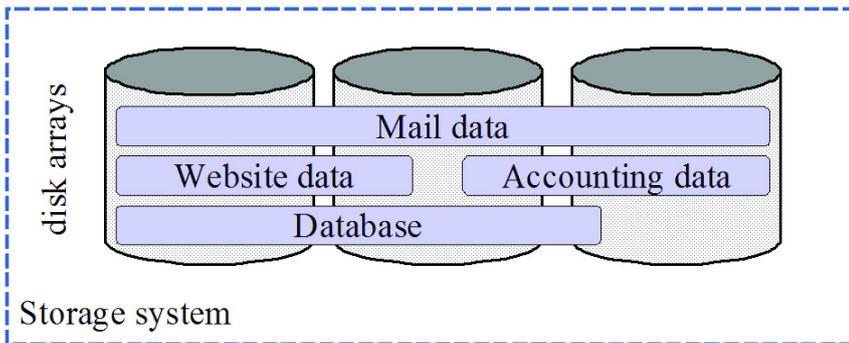


Figure 1: Typical layout of application data.

number of disk seeks. This is done using performance statistics provided by the storage server. Most storage servers provide, for each array and logical volume, statistics on the caching and workload type. The energy consumption of each physical component is computed using interpolation and the energy consumption dataset.

Our logical volume estimation framework deals separately with fixed and dynamic energy consumption. Our heuristic computes the fixed portion in a straightforward manner; each volume is charged proportionally to its capacity. The heuristic for the dynamic portion charges each logical volume based on its workload, relative to the workload of the storage server. The complexity of the heuristic stems from the fact that multiple logical volumes share the same physical resources. As a result, the dynamic energy consumption of one volume is affected by the workloads of all logical volumes.

The storage energy estimation framework is now freely available for early adopters from IBM's Open Process Automation Library (OPAL). The framework is implemented as an add-on module for IBM Tivoli Monitoring (ITM) and Tivoli Storage Productivity Center (TPC) customers.

Our module estimates the energy consumption for DS8000 and DS6000 storage servers, arrays, and logical volumes, and graphically shows the energy consumption as it changes over time.

Our framework for evaluating the energy consumption of logical volumes is an important step towards understanding the total cost of running enterprise applications. The total energy cost of an application is the sum of its compute, storage and network energy consumption.

This work began in 2007 and is being carried out primarily in the IBM Haifa Research Lab. Future activities will incor-

porate energy management functions for storage arrays and logical volumes.

**Links:**

- <http://www.haifa.ibm.com/projects/storage/pmss/index.shtml>
- <http://www.ibm.com/software/tivoli/opal/?NavCode=1TW10TM8F>
- <http://www-01.ibm.com/software/brandcatalog/portal/opal>

**Please contact:**

Doron Chen  
IBM, Israel  
Tel: +972 3768 9401  
E-mail: [cdoron@il.ibm.com](mailto:cdoron@il.ibm.com)

Ronen I. Kat  
IBM, Israel  
Tel: +972 3768 9493  
E-mail: [ronenkat@il.ibm.com](mailto:ronenkat@il.ibm.com)

Kalman Meth  
IBM, Israel  
Tel: +972 4829 6341  
E-mail: [meth@il.ibm.com](mailto:meth@il.ibm.com)

## Energy-Aware Storage Benchmarks

by Roger Kahn, Ronen I. Kat and Carlos Pratt

*Modern enterprise storage systems have increasing capacity and a need for increased throughput. Currently up to 40 percent of the energy consumption in data centres is associated with storage systems. One IBM research focus is on energy benchmarks that provide insights into the energy consumption of storage systems; specifically, how the workload performed by the user affects energy consumption.*

The architecture of a storage server differs from a computing server. In addition to the computing resources (eg processor, memory) found in a computing server, a storage system has internal storage networks and a large number of storage devices, currently disk drives. A large portion of the energy is consumed by these disk drives, primarily by their mechanical spindle motors.

The energy consumption of a storage system may be partitioned into the energy consumption of the storage devices (eg disk drives) and that of the other components of the storage system. Concurrently, the energy consumption can be broken down into energy that is not related to user workload, termed idle energy consumption, and energy that is related to user workload, termed dynamic energy consumption. The total

energy consumed by a storage system is the sum of the idle and dynamic energy.

The idle portion of storage system energy consumption is typically 70% to 80% of the maximal storage energy consumption. This is a far higher percentage than the idle energy consumption of a computing server, and is caused by the need to keep disk drives spinning at all times. While some

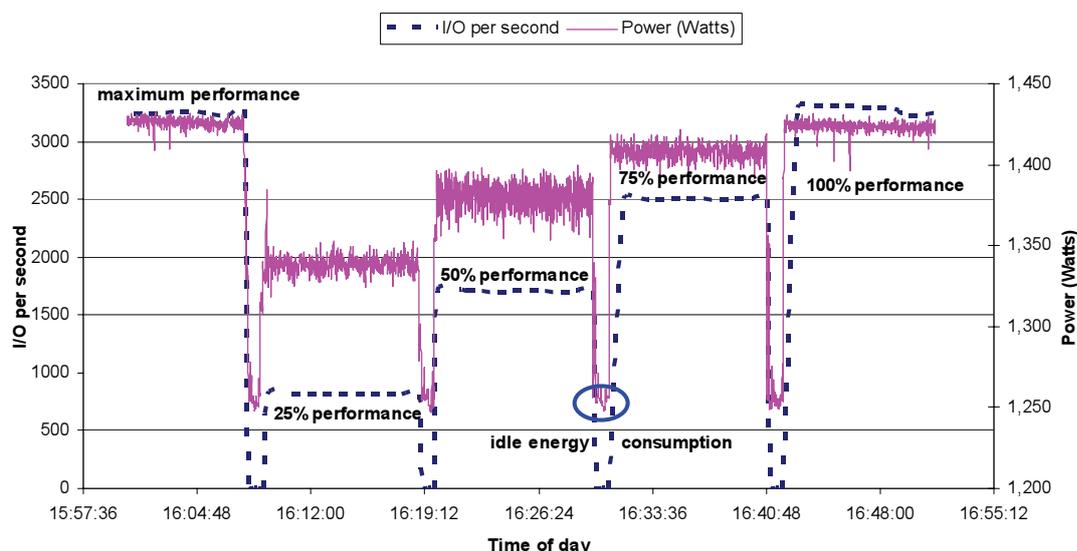


Figure 1:  
Energy and  
performance  
benchmark for a  
mid-range enterprise  
storage system.

storage systems allow disks to spin down, enterprise systems that rely on providing instant access to data cannot do this. The idle portion of the energy consumption also includes background housekeeping tasks such as media scans, parity checks, etc.

In April 2009, the Storage Networking Industry Association (SNIA) released a first draft for public review of the 'SNIA Green Storage Power Measurement Technical Specification'. The draft focuses mainly on the idle energy consumption portion of storage systems. In addition, the draft has a comprehensive taxonomy that helps the user to map energy consumption of storage systems based on capabilities and workloads.

The dynamic energy consumption of enterprise storage is directly related to the workload of the storage system. The amount of dynamic energy consumed is a function of the workload and performance of the storage system. As the storage system increases the utilization of the computing resources, network and storage devices, the dynamic energy consumed increases accordingly.

The Storage Performance Council (SPC) recently released the SPC-1C/E benchmark toolkit, which can drive storage systems with up to 48 storage devices, either solid-state drives (SSDs) or disk drives. The SPC-1C/E workload simulates an online transactional processing (OLTP) environment and shows the correlation between performance and energy consumption.

The techniques employed by SNIA and SPC are very similar to those published for servers by the Standard Performance Evaluation Corporation (SPEC). IBM labs have measured the energy consumption and performance of different storage systems for both SNIA and SPC. IBM is using standard energy measurement equipment to measure energy consumption. In addition, energy measurements and performance monitoring are synchronized in order to report the effect of the user workload on energy consumption. The graph in Figure 1 demonstrates an example workload and energy consumption benchmark for a mid-range enterprise storage system. The benchmark starts by exercising the storage to its highest performance and energy consumption state. This is followed by running workloads that are equivalent to 25%, 50%, 75% and 100% of the maximum performance. For each step, the workload (in I/O per second) and energy consumption are shown. Between benchmark steps, the idle energy consumption is observed. In this case, the idle portion it is approximately 87% of the maximum energy consumption of the storage system.

For more details on SNIA and SPC benchmarks see the links provided at the end of this article.

The future holds drastic changes for storage systems. The introduction of SSDs will have a significant effect on the energy consumption of storage systems. Also, adding different technologies and techniques such as having 'dormant' and 'active' drives will fur-

ther reduce the idle portion of the energy consumption.

The goal of the energy benchmarks in development is to demonstrate a correlation between the user workload and the storage energy consumption and hence help design energy-proportional storage systems. Our work on storage benchmarks began in 2007 and is performed by IBM's Haifa Research Lab and Tucson performance lab. Future activities include refining models that will aid in the deployment and design of energy-proportional storage systems, and determining how they will affect the bottom line of the customer.

Stay tuned!

#### Links:

<http://www.haifa.ibm.com/projects/storage/pmss/index.shtml>  
<http://www.snia.org/forums/green/>  
<http://www.storageperformance.org>  
[http://www.spec.org/power\\_ssj2008/](http://www.spec.org/power_ssj2008/)

#### Please contact:

Roger Kahn  
 IBM Haifa Research Lab  
 Tel: +972 3768 9527  
 E-mail: rogerk@il.ibm.com

Ronen I. Kat  
 IBM Haifa Research Lab  
 Tel: +972 3768 9493  
 E-mail: ronenskat@il.ibm.com

Carlos Pratt  
 IBM Tucson Arizona  
 Tel: +1 520 799 5409  
 E-mail: jcpratt@us.ibm.com

# Power-Efficient Packet Classifier for Next-Generation Routers

by Zhen Liu, Alan Kennedy, Olga Ormond and Xiaojun Wang

*Building high-performance and power-efficient packet classifiers is important for the success of next-generation networking devices. The Network Processing Group, part of the Network Innovations Centre (NIC) in the Research Institute for Networks and Communications Engineering (RINCE) at Dublin City University (DCU), is devoted to research in this area.*

Packet classification involves matching several fields extracted from a packet header to a set of pre-defined rules in order to determine the follow-up action to be performed on the packet by networking devices. As one of the key functions of a router/switch, packet classification is widely used in applications such as policy-based routing, Quality of Service (QoS), Virtual Private Networks (VPN), network security (eg firewalls and intrusion detection) and sophisticated traffic billing. Transmission line speeds keep increasing. For example, the state-of-art line rate of OC-768 (40 Gbps), used in optical fibre backbone networks, demands a worst-case processing speed of 125 million packets per second. In addition to meeting the ever-increasing line rates, growing attention has been paid to reducing power consumption in the design of next-generation networking devices, since it is desirable for the packet classifier to consume as little energy as possible.

The most commonly used header fields in packet classification form a 5-tuple, which includes source IP address and destination IP address for prefix matching, source port and destination port for range matching, and protocol number for exact or wildcard matching. The typical size of a rule-set ranges from hundreds to millions of rules, depending on the application and location of the router/switch. Due to the complexity of packet classification, Ternary Content Addressable Memory (TCAM) is frequently used, which can guarantee millions of searches per second by examining all rules simultaneously. However, the high power consumption caused by the parallel comparison in TCAM makes it less likely to be incorporated in the design of future power-efficient networking equipment.

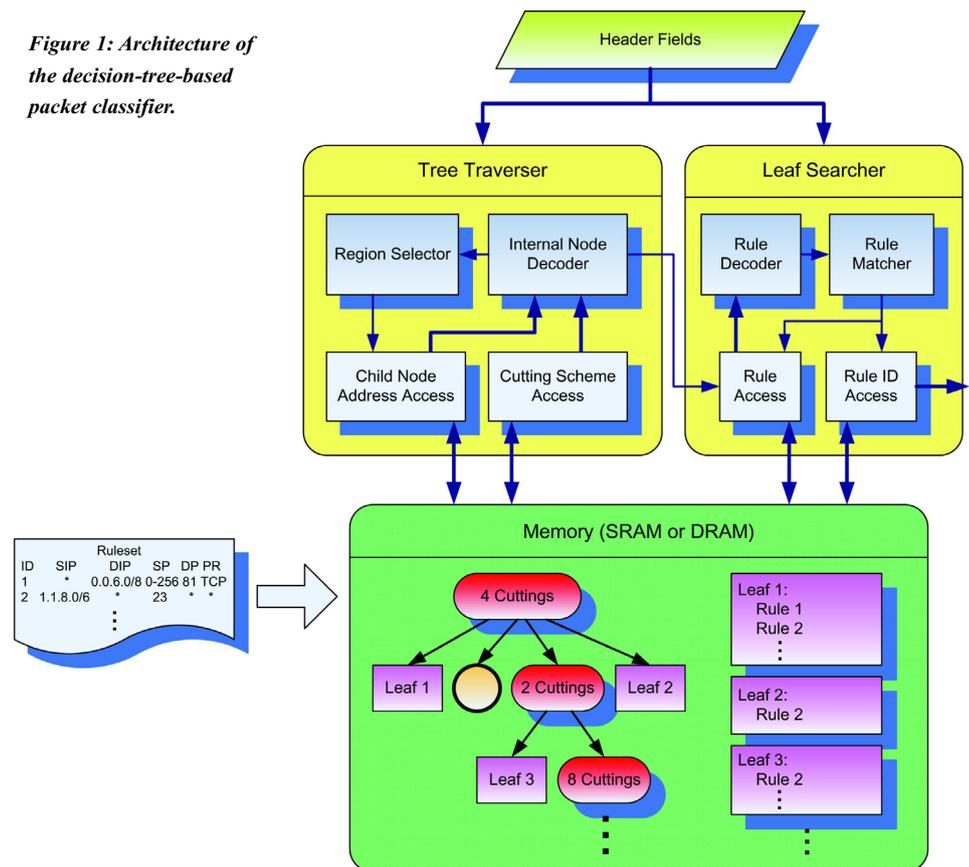
Our project aims to design a packet classifier that meets the challenges of both high speed and low power consumption.

In order to achieve this goal, we choose to implement in hardware a packet classification algorithm (HyperCuts) based on a decision tree, meaning TCAM can be replaced with energy-efficient memory devices such as SRAM or DRAM. This type of algorithm recursively cuts the hyperspace represented by the rule-set into smaller hyper-boxes called Regions along some selected dimensions, forming a decision tree, until the number of rules contained in

a small number of memory accesses are needed in order to guarantee the throughput.

The major parts of the packet classifier are the Tree Traverser and Leaf Searcher (see Figure 1). Each internal node contains the cutting scheme to be performed on the hyperspace represented by this node, and the starting address of each child node. Other information, such as whether the child node

*Figure 1: Architecture of the decision-tree-based packet classifier.*



the resulting hyper-boxes is smaller than a predefined threshold. When a packet is received, the classifier traverses down the decision tree, based on the value of header fields, until a leaf node is found and searched for the matching rules. The structure and parameters of the packet classifier are carefully selected to make sure that only

a non-empty leaf, is also coded. In each leaf node, rules are stored in the order of priority, along with their IDs. When the cutting scheme is fetched and interpreted, the Region corresponding to the header fields is selected, ie the starting address of this child node will be read out from memory and used for the next round of tree traversing. If a

non-empty leaf is encountered, the control is passed to Leaf Searcher. The rules are compared against packet header fields one by one, until either a matching rule is found or all of the rules have been examined.

The power consumption of the packet classifier can be further reduced by exploiting the common fluctuations in network traffic. For example, traffic volume during the night might be less than one third of the peak day rate. This phenomenon implies that the packet classifier need not always run at its highest possible clock speed. When the packet arrival rate is low, the packet classifier can reduce its working frequency to an appropriate level in order

to save energy. In our project, we use a header buffer to monitor changes in network traffic, with the number of outstanding packet headers waiting for classification working as an indicator of the frequency required for the packet classifier.

Our packet classifier can be easily implemented in hardware (FPGA or ASIC), working as an individual component on a line card or integrated into a network processor. The experiments performed on sample implementations in Altera FPGA and ASIC show that our packet classifier can achieve packet classification throughput of up to OC-768 line rate with significantly lower power consumption than TCAM implementations.

#### Link:

<http://wiki.eeng.dcu.ie/nic/278-EE.html>

#### Please contact:

Olga Ormond  
Network Innovations Centre, RINCE  
Dublin City University, Ireland  
Tel: +353 1 700 5444  
E-mail: [ormond@eeng.dcu.ie](mailto:ormond@eeng.dcu.ie)

Xiaojun Wang  
Network Innovations Centre, RINCE  
Dublin City University, Ireland  
Tel: +353 1 700 5808  
E-mail: [xiaojun.wang@dcu.ie](mailto:xiaojun.wang@dcu.ie)

## EcoNets: Economic and Energy-Efficient Bandwidth Allocation in Future Networks

by David Hausheer

*The EcoNets project aims to develop new mechanisms for an economic and energy-efficient bandwidth allocation in future networks. Cooperation and resource sharing combined with new allocation schemes will provide appropriate incentives to provide bandwidth only where and when it is needed.*

There has recently been tremendous technological progress in the area of Internet-based communications, with router hardware now able to process data at a rate of several terabits per second. At the same time, the proliferation of wireless technology has enabled users to be 'connected' anytime and anywhere in the world. However, it is important to consider all the costs that arise from such new technology. Besides acquisition and maintenance costs, energy consumption is becoming increasingly significant. Rising energy costs and the need to reduce carbon emissions have led to an increased awareness of the need to improve energy efficiency wherever possible. For computing equipment such as monitors and desktop computers, standards like EnergyStar exist to ensure that energy resources are used efficiently. However, little attention has so far been paid to energy consumption in networks, and comparable standards for networking equipment do not yet exist. This is despite the fact that energy consumption of network devices is a substantial and growing cost factor due to higher-capacity equipment that consumes more

energy - up to 50% of the total cost of ownership according to some estimates.

Fortunately, there is potential to improve energy efficiency in networks, as despite their energy consumption being high, their utilization is generally below 5%. Access points of wireless networks are idle much of the time, and consume energy whether or not they are in use. This energy consumption could be reduced by cooperation between different wireless network providers.

Recent advances in the area of network virtualization enable the provisioning of bandwidth 'on demand'. Besides providing numerous other benefits relating to security, flexibility and reliability, this technology enables the transparent sharing of physical network equipment between different customers of the same network provider. An important aspect of network virtualization that has received little attention so far is its potential to significantly reduce energy costs, as it allows customers to gradually adapt bandwidth capacity to current demand. However, suitable business models for such on-demand bandwidth services

have not yet evolved, and without appropriate settlement schemes providers have few incentives to cooperate.

#### EcoNets Objectives

EcoNets is a postdoctoral project supported by a fellowship from the Swiss National Science Foundation (SNSF) in collaboration with the University of California at Berkeley. The project, which began in late 2009, aims to develop new incentive schemes and allocation mechanisms for economic and energy-efficient bandwidth provisioning in fixed and wireless network infrastructures of the future. The following key economic and technical research issues have been identified and will be addressed in EcoNets:

- Energy-efficient bandwidth provisioning: A key part of bandwidth provisioning costs is the energy cost, making minimum consumption of energy resources essential. Even small energy savings can have a tremendous impact if summed over a huge number of networking devices. This objective is in line with EU plans to reduce primary energy use by 20% before 2020. However, this ambitious

goal can only be reached if energy efficiency is improved on all levels.

- **Bandwidth on demand:** New bandwidth allocation schemes and business models need to be developed to support the on-demand provision of bandwidth services to customers at the right location, at the right time and in the right quantity. However, the effect of such bandwidth-on-demand allocation schemes on higher-level routing and transport protocols needs to be investigated.
- **Economically efficient incentives:** The design of resource allocation policies and incentives for cooperation in this context is a difficult problem. Incentive mechanisms should lead, ideally, to an economically efficient allocation and use of bandwidth services. Auctions are a standard way to achieve such objectives, but the distributed environment and the different types of resource involved pose significant challenges to their implementation.
- **Scalable and robust bandwidth allocation:** Any bandwidth provisioning scheme needs to be able to scale to a very large amount of bandwidth offered by many providers to many customers, and over a very large

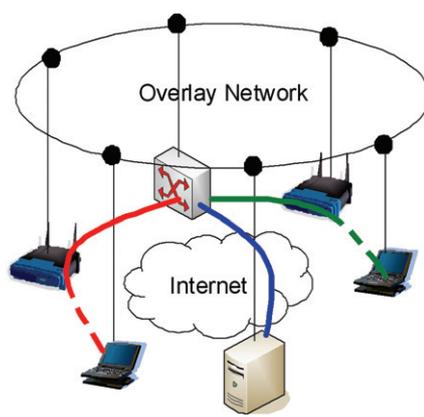


Figure 1: EcoNets Architecture.

number of network devices. The support of bandwidth allocation in a fully decentralized manner, such as based on peer-to-peer (P2P) concepts (eg PeerMart), shows advantages in terms of robustness and scalability for large systems.

EcoNets will design allocation mechanisms to allow customers to reserve bandwidth capacity on demand and in advance. Reserved capacity that remains unused may later be offered to other customers. Thus, customers can themselves

become providers of bandwidth services. The key architectural idea is to organize the different network entities in an overlay network in which they become peers (see. Figure 1). This peer awareness will allow an optimal allocation of bandwidth to be reached. Customers will benefit from these mechanisms as their bandwidth needs can be met in a more scalable and cost-effective manner. Finally, by following a generic bandwidth allocation approach, EcoNets will be applicable to both fixed and wireless network scenarios.

#### Links:

EcoNets Project:

<http://www.csg.uzh.ch/research/econets>

PeerMart Homepage:

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

Dagstuhl Seminar on Bandwidth on Demand:

<http://www.dagstuhl.de/09072>

#### Please contact:

David Hausheer

University of Zurich, IFI, Switzerland

Tel: +41 44 635 43 72

E-mail: [hausheer@ifi.uzh.ch](mailto:hausheer@ifi.uzh.ch)

## A BitTorrent Proxy for Green Internet File Sharing

by Giuseppe Anastasi, Marco Conti and Andrea Passarella

**Greening the Internet is becoming a major research topic for the networking community. We are working towards a suite of 'Green P2P Solutions' that will drastically reduce the energy footprint of P2P applications.**

Several reports indicate that the total energy consumed every day by people connecting to the Internet to carry out their daily activities is already very high, and is expected to increase in the near future as the Internet's role in society expands. About 74 TeraWatt hours (TWh) per year of electricity are consumed by the Internet. Although this accounts, for example, for just 2% of the USA energy consumption, it is nevertheless a remarkable number. It is estimated that about 32% of this energy could be saved just by using energy management techniques on Internet devices.

Researchers are tending to direct their attention to the network edges, ie data

centres and PCs, since there is less room for energy saving inside the Internet core. It is particularly relevant to focus on PCs, as these devices are widespread and numerous. In 2007, data centres in the USA accounted for approximately 2 TWh, while PCs accounted for approximately 16 TWh. Some of this energy consumption could be easily avoided by just switching off overnight. However, many PCs are intentionally left on by their users, to perform networking activities such as P2P file sharing.

It is therefore sensible to focus on 'green' P2P solutions. Recent studies (H. Schulze, K. Mochalski, "The

Impact of Peer-To-Peer file sharing, voice over IP, Skype, Joost, Instant Messaging, One-Click Hosting and Media Streaming such as YouTube on the Internet", IPOQUE – Internet Study 2007, Leipzig, Germany, September 2007.) indicate that 40-73% of Internet traffic is P2P, with BitTorrent being the most popular protocol, accounting for 50-75% of the overall P2P traffic. It is also expected that P2P architectures will play a key role in the design of the Future Internet, and the P2P concept will be exploited well beyond the capabilities of current P2P applications (eg it is expected that P2P will be increasingly part of the Internet core).

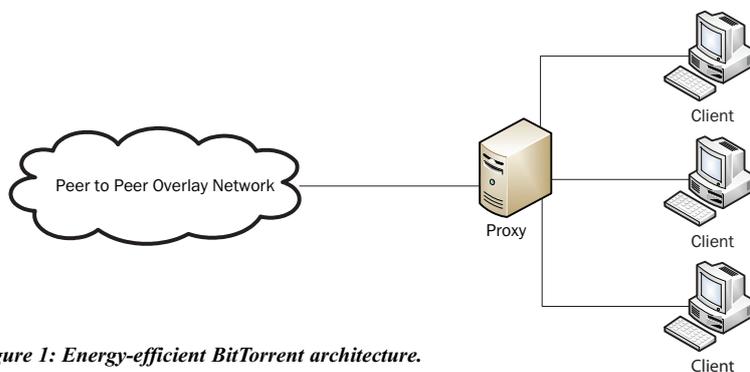


Figure 1: Energy-efficient BitTorrent architecture.

Motivated by these figures and trends, we are modifying conventional P2P architectures to make them ‘energy-friendly’. Our overarching goal is to obtain a suite of green P2P solutions. They should guarantee a significant energy saving with respect to what is possible today, and should be compatible with current de-facto standard protocols, so as to be deployed in a smooth and incremental way.

As a first effort towards this goal, we have studied an energy-efficient version of BitTorrent, which, given its popularity, should maximize the possible energetic impact of a green P2P solution.

The legacy BitTorrent architecture is not energy-friendly. BitTorrent peers must stay connected during the whole file download, which may take several hours. Simply powering them off is not viable. If a peer is downloading content, powering it off does not provide any energy saving as the download stops when the peer is turned off. Powering off peers that are not downloading files (but are sharing content) is also not an efficient solution, as it would result in decreased performance of the swarms in which they participate. Finally, coordinated ways of powering those peers are also not appropriate as they would

require a central control, which is in conflict with the BitTorrent design.

To overcome these drawbacks we have designed and implemented a proxy-based BitTorrent architecture (Figure 1). We assume a standard LAN environment where several users run BitTorrent on their PCs. One PC in the LAN acts as a BitTorrent proxy (BT proxy) between the peers and the rest of the network. The BT proxy can be either a dedicated PC or, better, a PC that must be continuously active for other reasons. The basic idea is that peers ‘behind’ the BT proxy ask the proxy to download the requested content on their behalf. The BT proxy participates in the conventional BitTorrent overlay, and takes care of all the downloads of the peers behind it. While downloads are in progress, these peers can be switched off without stopping the requested downloads. The requested files are transferred from the proxy to the peers upon completion. As the bandwidth available between clients and the proxy is typically higher than the download rate in the BitTorrent network, the time needed to power the users’ PCs can be significantly reduced.

In this design, modifications are only required at the BT proxy and at the users’ PCs behind the proxy, and are

thus confined to a single LAN. Different BT proxies on different LANs are completely independent. This architecture is thus scalable, as it requires neither modifications of the BitTorrent global architecture nor global coordination. It will also support mobile clients accessing the Internet, eg through a WiFi Access Point connected to the LAN where the BT proxy is running, and more generally is a solution to enable asynchronous BitTorrent downloads, which are not supported by the conventional BitTorrent architecture.

Figure 2 shows an example of the energy saving that can be achieved using the BT proxy (results are obtained from a real Internet prototype). The performance index is the percentage of energy consumed by our ‘green BT’ solution relative to that of the conventional BT, when an increasing number of clients download large files (in the range [3.95, 4.71] GB). We consider both the case in which the BT proxy runs on a PC that must be continuously powered for other reasons (top curve), and that in which it runs on a dedicated PC (bottom curve). We can see that when an active PC can be exploited, the energy saved does not depend on the number of clients and is approximately 95% for each peer. On the other hand, when we use a dedicated PC, the energy saving increases with the number of clients and asymptotically converges to the previous constant value (ie, about 95%). However, even with two peers, the energy saving is larger than 60%. These results clearly show the effectiveness of the proxy-based architecture from the energy-saving standpoint.

**Link:**  
<http://info.iet.unipi.it/~anastasi/index.html>

**Please contact:**  
 Giuseppe Anastasi  
 Dept. of Information Engineering,  
 University of Pisa, Italy  
 Tel: +39 050 2217 559  
 E-mail: giuseppe.anastasi@iet.unipi.it

Marco Conti  
 IIT-CNR, Italy  
 Tel: +39 050 315 3062  
 E-mail: marco.conti@iit.cnr.it

Andrea Passarella  
 IIT-CNR, Italy  
 Tel: +39 050 315 3269  
 E-mail: andrea.passarella@iit.cnr.it

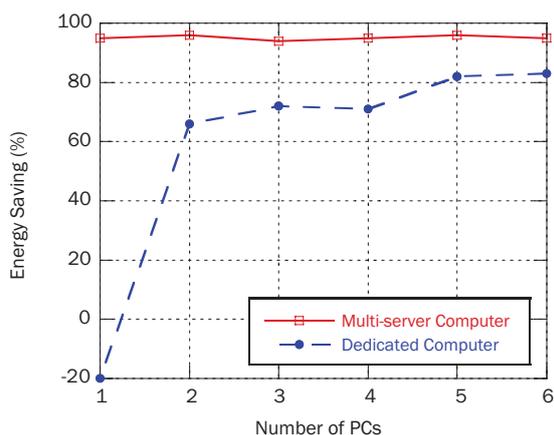


Figure 2: Energy saving vs. number of clients.

# Interactive Energy Management System in Households

by Tuan Anh Trinh and Sándor Plósz

*In the framework of the AIM project (a novel architecture for modelling, virtualizing and managing the energy consumption of household appliances), an energy management system for the home environment is being developed [1]. The challenge is to provide communication between the user, powered devices and the energy management system.*

The concept of sustainable development states that we are responsible for ensuring that the environment remains as suitable for future generations as it was for us. According to measurements, the ICT industry was responsible for about 2% of global CO<sub>2</sub> emissions in 2007, with this value projected to multiply in coming decades (SMART 2020: Enabling the low carbon economy in the information age; A report by The Climate Group on behalf of the Global

tion systems are centralized and less managed on the consumer side, with production being based on predictions. The billing of energy is done by reading the installed watt meters manually. Energy is sold at a fixed, predetermined price based on the observed consumption. As of yet, the logic to implement energy management functions is missing in households, but achieving it would involve users in conscious decision-making through resource manage-

functions and utility services are deployed under a common logic on a future 'home gateway'. In the household, the target is to create an Energy Management Device (EMD) which can provide basic energy management functions for existing appliances and which will speed up the spread of the technology until it is standardized. Although complete logic layer structure is being defined for the inter-working of components in the system, the physical layer

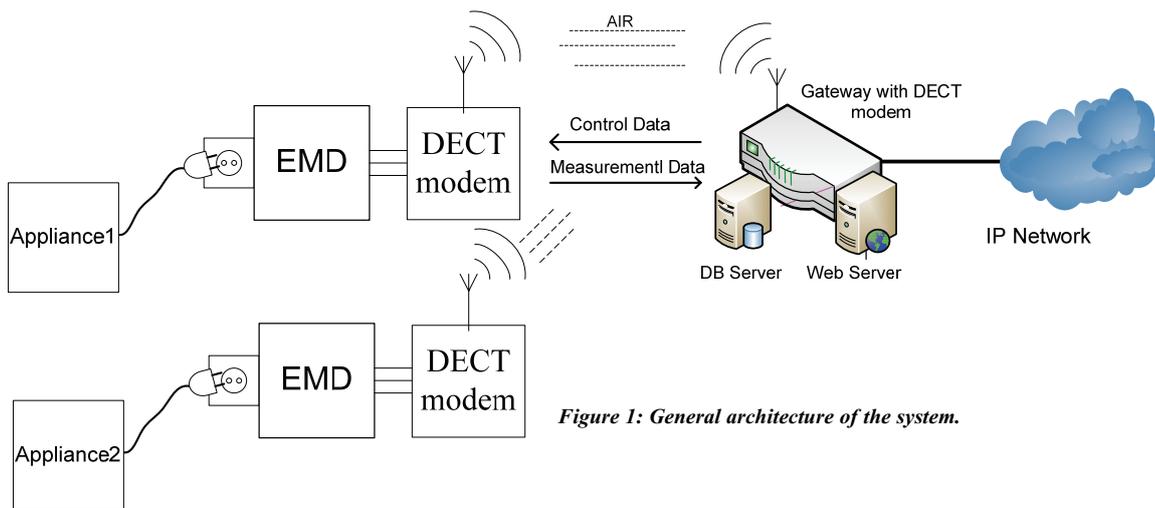


Figure 1: General architecture of the system.

eSustainability Initiative (GeSI), 2008). This issue is in large part related to the energy consumption of the devices and equipment in use. As a result, efficient energy management has recently received much attention from the ICT industry and the academic sphere alike.

Centralized energy production is becoming obsolete in consequence of the spread of methods that utilize alternative energy, which can be installed anywhere in small scale thereby making the grid more decentralized. The pressure of the principle of sustainable development is beginning to make a significant impact on the distribution of energy exploitation techniques. Most of today's energy production and distribu-

ment and dynamic pricing. The spreading of alternative energy source exploitation in households demands more intelligence by itself. The former consumer may become a provider by investing into energy production technologies using alternative forms of energy. In order to feed energy back to the grid smart power meters are needed.

AIM is one of a number of projects investigating the issues of energy management. Some concepts have already been implemented, such as smart grids dealing with decentralized energy systems. The purpose of AIM is to create an end-to-end system for connecting the appliances into the home network in which virtualized household appliance

communication interfaces are not strictly bound, allowing manufacturers to use their desired technology.

In this work, we first investigate the option of realizing an energy management system on a DECT (Digital Enhanced Cordless Technologies) interface, and the peculiarities of DECT and new generation standards; we also examine its suitability as a communication interface in the home. We then design an EMD with basic functions and integrate it with a system connecting to the home gateway. On the home gateway we implement logic for virtualizing the functions of the EMD and hosting it for remote accessibility via a Web server. The main idea behind the

EMD is on the one hand to involve the user in energy management decisions, and on the other to be able to connect the Utility (energy provider) to the home environment. The Utility has a great interest in gaining some influence, even indirectly, in the home environment.

Our system provides the missing communication between the Utility, the consumer and the energy management system. The following features are available:

- monitoring of energy consumption of individual appliances with the EMD
- control of individual appliances remotely through the EMD

- energy management logic on the home gateway connecting the management systems of the home and the Utility
- real-time monitoring of the household's consumption by the Utility.
- electricity price information request can be made to the Utility; cost of operating the appliance can be pre-calculated based on energy profiles
- resource management by the Utility; energy can be pre-bought, with price based on the reserved energy for that period
- resource optimization; the Utility can propose resource shifting for favourable prices.

**Link:**

<http://www.ict-aim.eu/>

**Please contact:**

Tuan Anh Trinh  
Budapest University of Technology and Economics, Hungary  
E-mail: [trinh@tmit.bme.hu](mailto:trinh@tmit.bme.hu)

**Sándor Plósz**

Infineon Technologies, AG  
E-mail: [Sandor.Plosz@infineon.com](mailto:Sandor.Plosz@infineon.com)

## Intelligent Systems for Green Developments

by Han La Poutré, Wil Kling and Sjef Cobben

***Alternative local energy sources are becoming increasingly popular, creating a new network of small suppliers. Fluctuations in the supply from such sources may cause instability and inefficiency in electricity distribution networks. The IdeaNeD consortium in the Netherlands aims to solve these problems.***

Wind turbines, biomass, solar energy and storage facilities are some of the new green developments in energy supplies. In addition, iCHPs (Combined Heat and Power generators) are being introduced into homes, with conventional heating systems replaced by systems that can produce both heat and electricity. One can thus speak of decentralized power generation in an electricity distribution network (also called active power grids) with many actors.

Power production can fluctuate due, for instance, to variations in wind velocity or in the power supply from iCHPs. The demand for energy also varies. This makes balancing generation and load problematic and has large consequences for power flows. Large-scale use of electric cars increases these problems, with everybody recharging their car after rush hour. It is therefore necessary to improve the management of medium voltage (MV) and low voltage (LV) distribution networks, as most important developments are taking place in these networks.

At the same time, with smart metering and sensor systems appearing all over the network, the amount of available data has substantially increased, and this



***Intelligent systems guarantee efficiency and stability of networks of small alternative energy suppliers.***

can be used for management and control purposes in future networks. Due to the very large amounts of data, it is important that it be analysed and compressed, in order to be usable for network and system management.

The SenterNovem project 'Intelligent and Decentralized Management of

Networks and Data' (IdeaNeD), which started in mid-2009, is investigating the optimal management of such future networks. Researchers in IDEAneD will design computational methods and instruments that can deal with the large amounts of data and actors involved. The project is developing intelligent decentralized systems for management and data analysis via two main objectives. The first is decentralized management systems for distribution networks, in the form of prototype and proof-of-concept systems for testing, evaluation and development. Such systems will be used and developed in computer simulations with realistic data as well as (later on) with experimental electrical hardware systems in laboratories. They allow for 'what if' scenarios for different types of management and deployment of distribution networks. They will also form a base for future operational systems. These take the form of adaptive multi-agent systems, where a software agent is an intelligent software module designed for some area, actor or asset. Such software agents can be located at, for example, control or distribution centres, at intelligent ring main units, or with the users, for managing power cells and consumption. Pricing is one of the mechanisms that

could be used to accomplish efficient network management. Electricity costs and benefits for an actor can thus depend on the moment of use and supply, as in day and night rates. For any user or distributor, intelligent software can then determine at what times power is used or produced. An alternative control mechanism to be investigated is 'remote control', enabling electricity companies to have a certain degree of control over usage and supply from a distance.

The second objective is the development of tools that indicate the (future) state of the network. This will require data banks for intelligent network management, as well as conversion, analysis and compression tools for using real sensor data. The objective here is to

transform sensor data into control data (performance indicators), which can be used to manage the network and for visualization purposes. Supporting infrastructure for data and communication will also be developed. Important aspects to be controlled and analysed in networks include network loadings, origins of power flows, switching possibilities, dynamic stability and power quality.

Research into the control of distribution networks is now receiving international attention. The IdeaNeD project will lead to both new insights and practical products to be used by energy companies, network operators and industry. This makes the distribution network suitable for new developments; achieving decentralized management and control

is the key to decentralized supply and storage of electricity.

CWI is leading the IdeaNeD project, with the other partners being Eindhoven University of Technology, Alliander, KEMA, Stedin, Joulz, Phase to Phase, Early Minute and Alfen. The project is a close collaboration between experts from computer science and the electricity domain as well as between academic institutions and companies.

**Link:**

<http://www.cwi.nl/en/IDeaNeD>

**Please contact:**

Han La Poutré

CWI, The Netherlands

Tel: +31 20 592 4082

E-mail: [han.la.poutre@cwi.nl](mailto:han.la.poutre@cwi.nl)

## Computational Science for Future Energy Production

by Barry Koren

*At CWI two new PhD-projects are focusing on future energy production: one on controlled nuclear fusion and one on wind energy.*

Energy is of vital importance to human life in the modern world. We need it for primary necessities such as food, water, clothes and heating, as well as for transport, cooling, lighting, ICT, and so on. Energy consumption is proportional to living standard, which - on average - is increasing worldwide. At the same time, the world's population is increasing. Our fossil fuel resources are becoming scarcer and, at the same time, combustion of those resources is believed to be leading to unacceptable climate change and concomitant flooding risks in many of the world's lowland areas. The relevance of research on sources of energy to replace fossil fuels is evident.

Both CWI's PhD-projects make full use of numerical simulations, because experiments are either technically impossible or too expensive. Numerical mathematics can also be fruitfully used in future optimizations of both energy sources. The two PhD projects are fine examples of research for which computational science is indispensable.

### Controlled nuclear fusion

Currently in France, the International Thermonuclear Experimental Reactor (ITER, Figure 1) is under construction. True to its name, ITER is an international project, involving the EU, the USA, China, Russia, Japan, South Korea and India. It is expected to become operational around 2025, and is hoped to reach a power output-over-input ratio of 10; ITER's deuterium-tritium plasma will not yet be self-burning. To magnetically confine the plasma, ITER uses the tokamak concept. ITER's tokamak plasma will be in the so-called H-mode, which implies steep density gradients near the outer edge of the plasma and yields an enhanced plasma confinement. A consequent challenge is the possible occurrence of instabilities at the plasma's outer edge: edge localized modes (ELMs). ELMs, which show some resemblance to solar flares, may damage and finally ruin the expensive tokamak walls.

In February 2009, Willem Haverkort started his PhD research at CWI,

funded by the FOM Institute for Plasma Physics Rijnhuizen. The research goal is to investigate ITER ELMs by the further development and application of computational tools. In the first phase of the project, a study is being made of tokamak plasma equilibria in the presence of toroidal flow, using the generalized Grad-Shafranov equation. For these equilibrium studies, the existing FINESSE and PHOENIX software are extensively used, with FINESSE being extended for ITER's specific H-mode conditions. In the second phase, full, unsteady magnetohydrodynamic simulations will be made of the ITER plasma in H-mode. Here also, use will be made of existing software. A full MHD code will be coupled to FINESSE, and numerical extensions that appear to be necessary for ITER will be made. The software to be developed in this project is intended to be finally included in software for integrated ITER modelling and simulation.

### Wind-farm aerodynamics

A significant portion of the future energy needs of the Netherlands is to

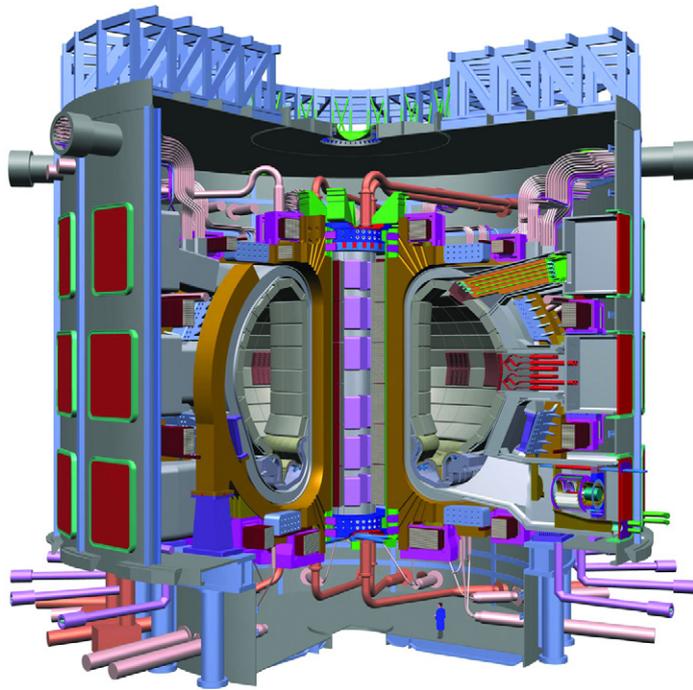


Figure 2: Artist's impression of ITER. Source: <http://www.fusie-energie.nl>

be produced by wind farms in the North Sea. A wind farm is a large set of coupled wind turbines, positioned in a matrix form. The advantages of wind farms as compared to sets of individual wind turbines are their smaller occupation of space and their lower construction and maintenance costs. The disadvantage is a reduced average power output per wind turbine. Designing wind farms involves creating, positioning and controlling each turbine such that the energy production of the

wind farm as a whole is maximal, its maintenance cost minimal and its life time maximal. Two mathematical challenges are that these objectives are conflicting, and that the situation is complicated by the uncertainty in wind. State-of-the-art stochastic, multi-objective optimization techniques are required to meet these objectives. Further, a good physical understanding of wind-farm wake aerodynamics is crucial. Whereas for controlled nuclear fusion most experimental research is

technically impossible, in wind-farm aerodynamics it is not. Nevertheless, wind-farm experiments have the disadvantage of being expensive at full scale, and involving upscaling difficulties at reduced scale. In fact, computational research is proving to be indispensable here as well.

In October 2008, funded by the Energy Research Centre of the Netherlands (ECN), Benjamin Sanderse started his PhD research, at both CWI and ECN, to develop a state-of-the-art computational method for simulating wind-farm wake aerodynamics. Proper turbulence modelling and accurate and efficient numerical simulation of the multiscale flow features are major research challenges in this project. We are opting for Large-Eddy Simulation to treat turbulence. The numerical methods to be developed and applied will preserve specific mathematical properties of the continuous equations.

**Links:**

<http://www.cwi.nl>  
<http://www.ecn.nl>  
<http://www.rijnhuizen.nl/>

**Please contact:**

Barry Koren  
 CWI, The Netherlands  
 Tel: +31 205924114  
 E-mail: [Barry.Koren@cwi.nl](mailto:Barry.Koren@cwi.nl)

## ENERPLAN - Green Logistic Solutions

by David Pisinger

***While the present global climate debate is to a large extent focused on mechanical solutions like electric cars and wind turbines, such technology is expensive and time-consuming to implement. Better IT-based logistics and planning tools with a focus on the environment may be an attractive alternative, since they do not need large investments, are fast to implement, and the underlying techniques are already mature.***

The EU has the goal of reducing CO<sub>2</sub> emissions by 20% within the next decade. The transportation sector is responsible for a large proportion of these emissions because of its reliance on fossil fuel. While the very nature of the industry means the introduction of alternative energy sources is not an immediately useful option, an alternative may be found in improving logistics.

The ENERPLAN research project (Energy Efficient Transportation

Planning) will develop intelligent IT-based planning tools for the containerized transportation sector, reducing energy consumption and thus environmental impact. The research project includes decision tools for planning a route network such that a higher load factor can be achieved, algorithms for filling containers and stowing vessels more efficiently, and methods for finding more efficient distribution paths. Pervasive computing methods using RFID and handheld devices are

used to integrate these approaches and provide decision support in the case of sudden changes, meaning superfluous energy consumption can be avoided. To allow end customers to visualize these efforts, decision tools that highlight the environmental impact of various transportation solutions are developed, making it possible for them to choose the most energy-efficient route.

The research involves cooperation between Maersk Line, DTU Manage-

ment Engineering and the IT-University in Copenhagen. Being the largest container shipping company, Maersk Line provides in-depth knowledge of the problems under scrutiny, and can transform the research results into actual energy-saving initiatives that have a significant impact on CO<sub>2</sub> emissions. The two university partners have a long experience in solving logistic problems in cooperation with industrial partners.

The goal of the project is to reduce energy consumption by 3-5% by designing more efficient route nets and improving logistic handling. For a large liner shipping company, this reduction amounts to the CO<sub>2</sub> emissions of a major Danish city.

It has now become possible to obtain dynamic information from the Internet using handheld computers and cellular phones, such that at any time we have a complete and reliable description of all current tasks and their execution progress. This means that we can start developing robust dynamic optimization systems. Such systems need to be sufficiently fast to reoptimize a plan almost instantly, very expressive so that they can handle nearly all realistic constraints, and be able to deliver decision support to the end-user such that an appropriate trade-off can be made between the cost and robustness of a solution.

The solution method follows a number of steps. First, a demand graph is constructed which describes the expected transportation from one port to another. Routes are then constructed by use of graph algorithms which aim at finding dense subgraphs that satisfy a number of properties. The cost of the flow in the proposed route net is evaluated by solving a generalized multicommodity flow problem. Based on the solution found, bottlenecks in the route net and non-competitive transportation paths are identified, and used as input to a new iteration.

The project has been awarded a 1 million EURO grant by the Danish Agency for Science Technology and Innovation within the special program 'Green IT'. The grant will finance two PhD and two post-doctorate positions at DTU and ITU to carry out research on mathematical optimization together with Maersk Line over a four-year period, starting in 2009.



Figure 1: Algorithms for filling containers more efficiently can help reduce CO<sub>2</sub> emissions.

ENERPLAN has its origin in classical optimization techniques, but brings a new dimension to the research field by also considering robustness, multi-criteria optimization, dynamic optimization and configuration. A great demand exists for dynamic decision systems, and the research will have a significant scientific impact. The solution methods and modeling techniques will be developed into prototype systems and tested on concrete customer data from the industry and government.

In classical operations research the focus has been to optimize a single criterion, typically profitability. ENERPLAN treats profitability and environmental impact as two equal objectives. Experience from other multi-criteria problems shows that a small decrease in one objective (profit) may lead to a substantial saving in the other objective (energy), resulting in a large impact for small cost. With the global focus on environmental issues intensifying, green logistics may be an important competitive parameter.

Green logistics is an often overlooked tool in the climate debate. Although green

logistics cannot solve all our environmental problems, it is a necessary supplement for reaching our goals on time and should play a central role in the UN climate conference in December 2009.

**Please contact:**  
David Pisinger  
DTU Management, Technical  
University of Denmark  
Tel: +45 4525 4555  
E-mail: pisinger@man.dtu.dk

Rune Møller Jensen  
IT University of Copenhagen,  
Denmark  
Tel: +45 7218 5048  
E-mail: rmj@itu.dk

Niels Rasmussen  
Maersk Line, Network Design,  
Denmark  
E-mail: niels.rasmussen@maersk.com  
Tel: +45 3363 4971

Mikkel Mühldorff Sigurd  
Maersk Line, Network Advanced  
Solutions, Denmark  
Tel: +45 3363 8157  
E-mail:  
mikkel.muholdorff.sigurd@maersk.com

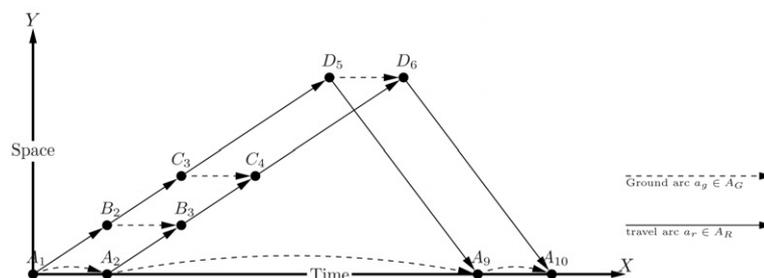


Figure 2: Time-space network with the schedule as time units. Service 1: A → B → C → D → A, vessel v<sub>1,1</sub> departing A at time t = 1 vessel v<sub>1,2</sub> departing A at time t = 2.

# A 3D Event-Based Silicon Retina Stereo Sensor

by Christoph Sulzbachner, Jürgen Kogler, Wilfried Kubinger and Erwin Schoitsch

*Conventional stereo vision systems and algorithms require very high processing power and are costly. For the many applications where moving objects (either source or target, or both) are the main goal to be detected, a new kind of bio-inspired analogue sensor that provides only event-triggered information, so-called silicon retina sensors, are providing a very fast and cost-efficient alternative.*

The challenge of stereo vision is the reconstruction of depth information in images of a scene captured from two different points of view. State-of-the-art stereo vision sensors use frame-based monochromatic or colour cameras. The corresponding stereo-matching algorithms are based on pixel patch correlation for the search of pixel correspondences. Generally, these algorithms contain the following steps: computation of matching cost, aggregation of cost, computation of disparity, and refinement of disparity. As a pre-processing step, the sensor needs to be calibrated and the images delivered by the cameras rectified; various methods and algorithms are available. This procedure is applied on whole images that are captured at a fixed frame rate. Due to the resolution of the sensors and the processing-intensive algorithms, the performance of these systems is quite low.

The silicon retina (SR) stereo sensor uses new sensor technology and an algorithmic approach to processing 3D stereo information. The SR sensor technology is based on bio-inspired analogue circuits. These sensors exploit a very efficient, asynchronous, event-driven data protocol that delivers infor-

mation only on variations of intensity ('event-triggered'), meaning data redundancy processing requirements are reduced considerably. Unaltered parts of a scene that have no intensity variation need neither be transmitted nor processed, and the amount of data depends on the motion of the scene. The second generation of the sensor has a resolution of 302x240 pixels, and measurements show that for a typical scene we anticipate about 2 mega data events per second. Depending on the protocol used, one data event requires a minimum of 32 bits.

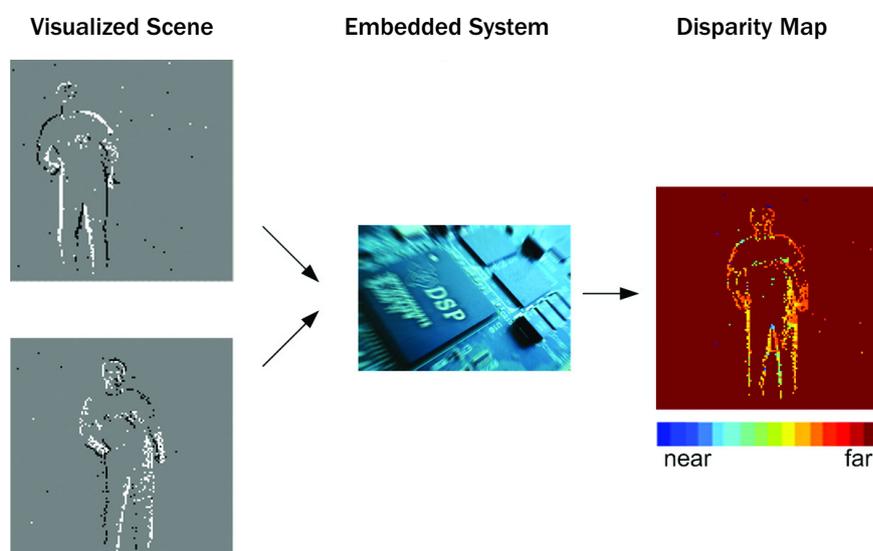
The requirements of the Silicon Retina Stereo Sensor (SRSS) are:

- **Detection Range:** objects must be detected with high confidence well before activation of countermeasures. Due to the system reaction time of 350ms, a detection range of 6 metres at an angular resolution of 4.2 pixel/° is required.
- **Field of view:** for the given sensor resolution of 128x128 pixels and the baseline 0.45m, lenses with a field of view of 30° are chosen. The large baseline is necessary to reach the required depth resolution of three consecutive detections during one

meter of movement in a distance of six meter.

- **System Reaction Time:** due to the requirement for reliability reasons of at least three consecutive detections, a time resolution of 5ms for the sensor is needed.
- **Location:** depends on application conditions; for example, if applied to moving vehicles in automotive applications, the sensor must be mounted on the side of the car and must be protected against typical outdoor conditions.

Figure 1 shows the components of the SRSS, including the captured scene and the resulting disparity map. The SRSS consists of two silicon retina imagers that are synchronized to have a common understanding of the local timing where variations of the intensity occur. The pair of imagers is called a silicon retina stereo imager (SRSI). One imager acts as a slave device, permitting a synchronization mechanism with the master imager. In Figure 1, only the scene visualized by accumulating the events for a specified time is shown. Both imagers are connected to the embedded system, which consists of two multi-core fixed-point digital signal processor (DSP)



*Figure 1: Overview of the SR stereo sensor, including a visualization of the scene and the resulting disparity map.*

with three cores each. One DSP is responsible for data acquisition, pre-processing of the asynchronous data, and miscellaneous objectives of the embedded framework. Another performs the main part of the event-based stereo vision algorithm in parallel on three cores.

A scene captured by the SRSI delivers two streams of variations of intensity as digital output. These asynchronous data streams are acquired and processed by the embedded system resulting in a disparity map of the captured scene based on the left imager. Conventional block-based and feature-based stereo algorithms have been shown to reduce the advantage of the asynchronous data interface and throttle the performance. Our novel algorithm approach is based

on locality and timely correlation of the asynchronous data event streams of both imagers. First, the sensor is calibrated to affect the distortion coefficients and the camera parameters. Then, the events received by the embedded system are undistorted and rectified to obtain matchable events lying on parallel and horizontal epipolar lines. The events from the left imager are correlated to the right imager and vice versa. This allows the disparity information of the scene to be calculated. Early prototypes showed that by using this algorithm the advantage of the SR technology could be fully exploited at very high processing framerates.

This technology is applied in the EC-funded (grant 216049) FP7 project 'Reliable Application-Specific Detection

of Road Users with Vehicle On-Board Sensors (ADOSE)'. The project focuses on the development and evaluation of new cost-efficient sensor technology for automotive safety solutions. For an overview of the ADOSE project, please see ERCIM News No. 78.

**Links:**

<http://www.ait.ac.at>

<http://www.adose-eu.org>

**Please contact:**

Christoph Sulzbachner, Jürgen Kogler, Wilfried Kubinger, Erwin Schoitsch  
AIT Austrian Institute of Technology  
GmbH /AARIT, Austria

E-mail: {christoph.sulzbachner, juergen.kogler, wilfried.kubinger, erwin.schoitsch}@ait.ac.at

## CoMem-XML: Exploring Context in Repositories of Construction Management Data

by Peter Demian and Panos Balatsoukas

*Engineers often seek to explore context in order to judge the relevance of a retrieved piece of information. The 'Finding needles in (hierarchical) haystacks' project, based in the Department of Civil and Building Engineering at Loughborough University, is examining new methods of information representation that will support exploration and understanding of context in hierarchical repositories of construction management projects.*

It has been demonstrated in the literature that civil engineers often seek to explore the context of a retrieved piece of information, in order to understand that item and use it appropriately. This behaviour can be attributed to the highly structured and hierarchical nature of engineering information; for example, a construction project can include details about a building as well as the individual components and sub-components of that building. For such information, context is defined by the hierarchical relationship between a piece of information and other information items within the hierarchy (such as components and sub-components in a parts hierarchy of a designed product).

However, the process of understanding and exploring context is more difficult to achieve in external information sources (such as knowledge management systems and corporate databases) than in internal resources (such as per-

sonal memory). Many of these external systems fail to provide contextual information to aid the understanding of retrieved items (eg highlighting an item's position in the granular hierarchy and exposing relationships with other parent and child items). The 'Finding needles in (hierarchical) haystacks' project attempts to address this problem by exploring and evaluating new methods and techniques of presenting information that will support exploration and understanding of context in hierarchical repositories of construction management projects.

The project, which is funded by the Leverhulme Trust, involves an interdisciplinary team of researchers from the construction management research group based at the Department of Civil and Building Engineering of Loughborough University, UK. This project builds upon previous research conducted at Stanford University

(California), by one of the authors of this article (Peter Demian), which explored the application of visualization in the design of corporate memories.

To date, a prototype query-driven repository of construction management projects, called CoMem-XML, has been built using XML technology. This system supports relevance ranking and presents the context of the retrieved information at various levels of granularity. The content stored in the CoMem-XML is hierarchical. A Project item (eg Imaginary Hotel in Manchester) is made up of multiple Discipline items (eg the architectural layout of the hotel or the structural frame of the hotel). Each Discipline item is made up of multiple Building Components (a particular room or structural column). Each Building Component is decomposed into two further levels: Subcomponent (eg a joint at

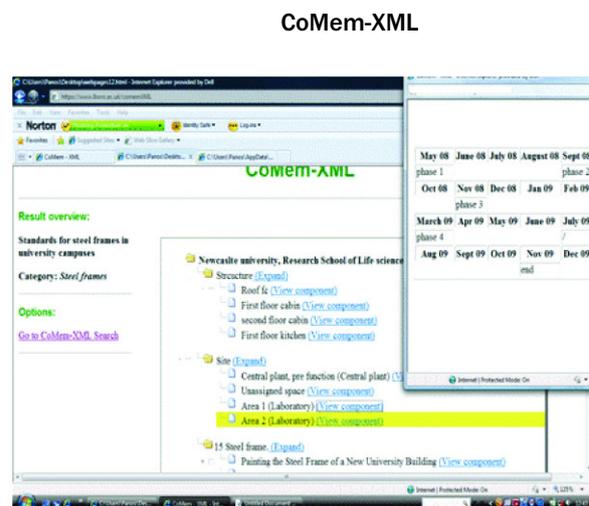
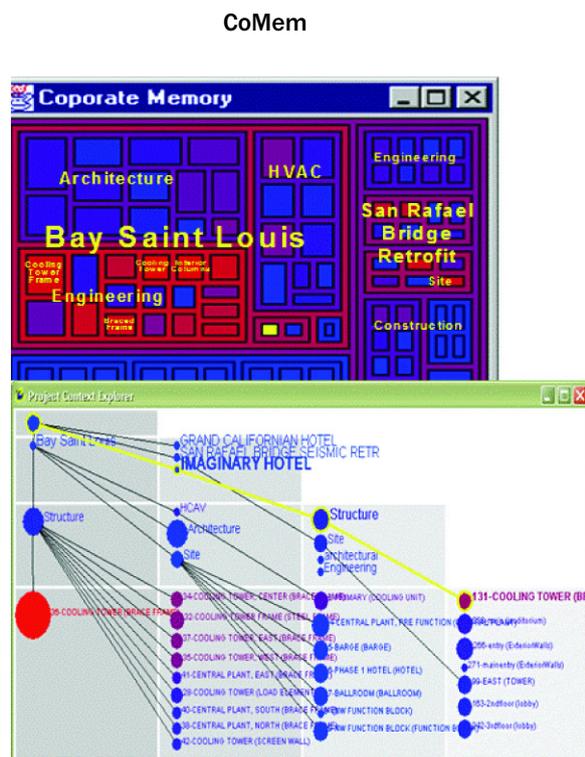


Figure 1: Visual and textual databases of engineering content.

the end of a column) and Sub-subcomponent (eg a bolt in the joint).

This hierarchy is used to organize not only objects from the CAD models in the repository, but also any textual or non-textual documents associated with construction projects: construction schedules, reports, journal papers, email archives, contracts and specifications. After a query is executed, the results are displayed as a list of Project items, ranked by relevance. The calculation of the relevance score of each Project is based on the average score of the individual constituent items of that Project (ie Discipline, Building Component, Subcomponent and Sub-subcomponent). In addition, within each Project all the relevant items are displayed in ranked order but within their actual context in the hierarchy. For example, if relevant information had been identified within a Building Component, then information about the Discipline within which the Building Component occurred is also displayed. In addition, the user has the option of exploring other Building Components and Subcomponents of that Discipline item, regardless of their relevance to the user's query.

The search result interface of this system thus communicates not simply

relevance in terms of the degree of similarity between a query and the item's content (as is the case for traditional query-driven information retrieval systems and search engines), but also supports understanding and exploration of that information, such as its context and organization within the product parts hierarchy.

An existing alternative to the CoMem-XML system, the original CoMem, applies information visualization techniques to display relevant information and facilitate browsing across a collection of construction projects. Users of this system are provided with an overview of the contents of the collection. When relevant information is identified from this overview, the context of the selected item can be explored in two interfaces that (i) identify and display related information in the hierarchy, and (ii) visualize the evolution history of that item.

Usability tests have shown that both CoMem and CoMem-XML can improve user performance and satisfaction when searching and judging the relevance of retrieved information, compared to typical browsing trees (eg Microsoft file explorer), search engines (eg Google) and repositories that present the retrieved information out of context.

**Please contact:**

Peter Demian  
 Department of Civil and Building  
 Engineering, Loughborough University  
 Tel: +44 1509 228541  
 E-mail: p.demian@lboro.ac.uk

# Route Optimization: How Efficient will the Proposed North Dublin Metro Be?

by John R. Walsh

In November 2005, the Irish government presented its 'Transport 21' plan for the future of transport infrastructure in Ireland. The largest prospective capital investment to date in Ireland and occurring under the auspices of the National Development Plan, the work was anticipated to occur over the period 2006 to 2015.

The single largest element, the construction of a metro system for the greater Dublin area, is yet to commence. The plan comprises two metro lines: Metro North linking the city centre with the airport and continuing to north county Dublin, and Metro West, linking outer Dublin centres Tallaght, Clondalkin, Liffey Valley and Blanchardstown, with connections through the city centre, to the Metro North and existing rapid transit (Luas Red line). Metro West is presently at the stage of designing lines and stops,

whilst Metro North is reported to be at the 'permission to build and operate' stage.

The Metro North line presents interesting features: consisting of underground, surface and elevated tracks over a total length of 18 kilometres, 15 initial stops are planned, with some future additions anticipated. In the current economic climate, cost estimates ranging from €3-6 billion are inevitably a serious concern (for commercial reasons, the Rail Procurement Agency has

not disclosed expected costs in full). A framework for modelling impact scenarios is essential.

In earlier stages of the project, route options and the effect on properties in the vicinity of the line were identified, both during and after construction. This was supported by work of the Dublin Transport Office (DTO), using SATURN models of optimal flow across the road traffic network. SATURN (Simulation and Assignment of Traffic in Urban Road Networks) is

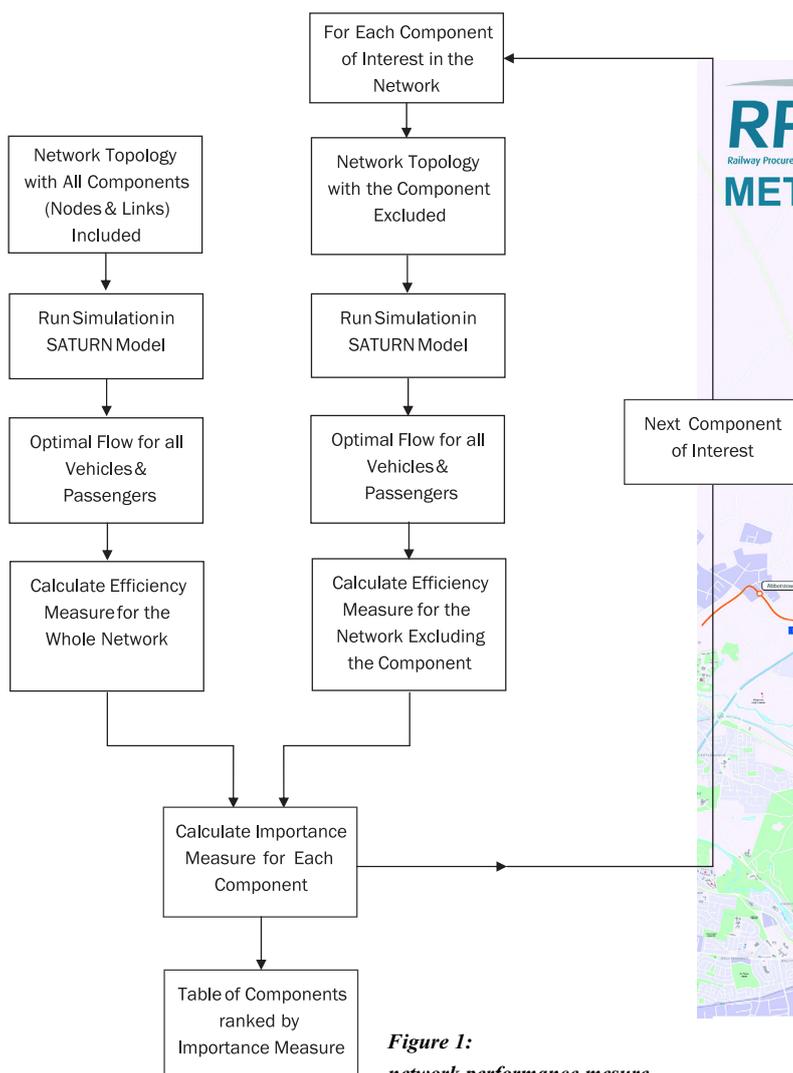


Figure 1: network performance measure.

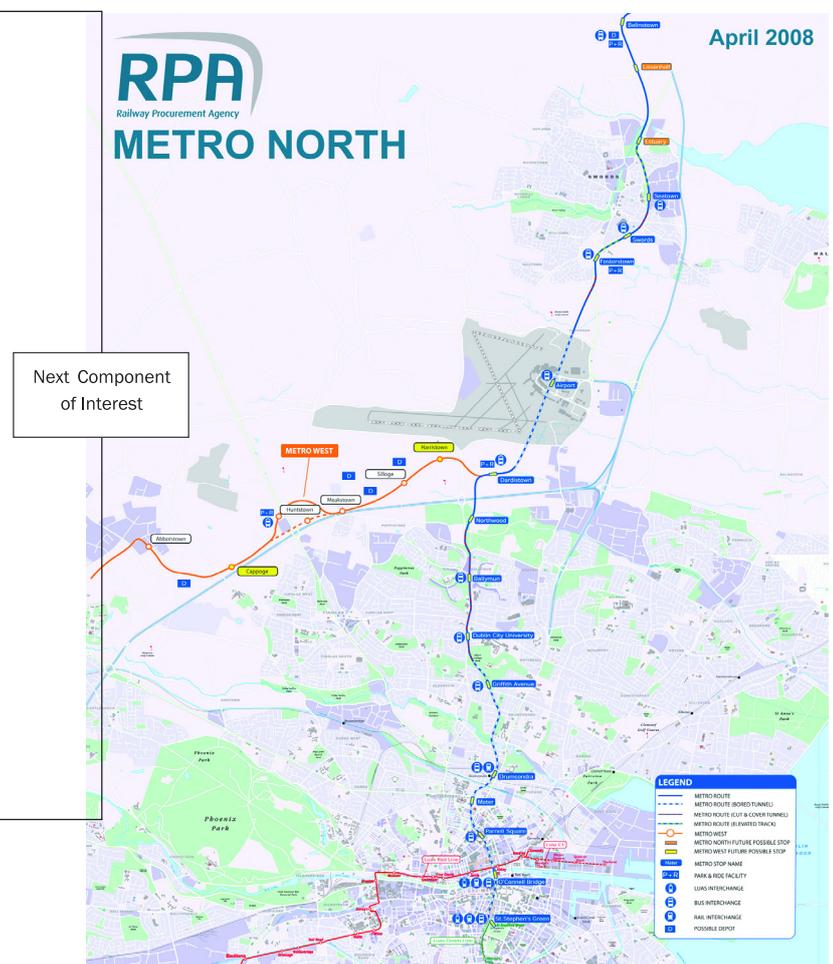


Figure 2: The planned Dublin Metro North line. Source: <http://www.transport21.ie/>

the model used by the DTO to help predict, for example, the impact on traffic of introducing Luas, building the Dublin Port Tunnel and completing the C-Ring motorway. The model is thus the principal design and evaluation tool for these and all major road and public transport proposals currently being planned and implemented in Dublin. The final proposed route for the Metro is a compromise between earlier options, but further assessment is needed, not least to address the network's robustness to failure. One option is to consider an importance factor for each of the links and nodes.

Whilst the SATURN model is not directly concerned with robustness of the network, it can be used, in conjunction with the key system equations of Nagurney and Qiang (2007, "A network efficiency measure for congested networks." *Europhysics Letters* 79(38005): 1-5), to look at network efficiency, together with the importance of individual network components.

Specifically, following Nagurney and Qiang (2007), given the topology of the network and the demand for transport across it, the measure of network per-

formance/efficiency is based on summing the ratio of demand to equilibrium disutility (minimal path cost) for each of the origin/destination (O/D) pairs in the network, and then scaling this by the total number of O/D pairs. The importance measure for a given component then depends on the ratio of the difference between the efficiency measures for the network with and without that component, to the efficiency measure of the network with all components included (see the flow diagram in Figure 1).

Using this approach, the importance of each link in the proposed Metro line and each station (node) along the line can be calculated and ranked to show its relative importance within the whole transport network.

Whilst the Metro line is itself a 'linear' network, this method enables us to assess it within the overall transport network, whereby users of the system can make choices regarding the routes and mode of transport.

Several alternative transport systems have been introduced in Dublin over the last three decades. The Dublin Area

Rapid Transport system (DART) system (which came in to operation in 1984) increased its passenger capacity by 12.5% in 2000, and by a further 19.6% of the original figure in 2003 to meet demand. Similarly, the newer road-based light rail (Luas Green and Red lines) has seen a 65% increase in the number of trams. A metro system, serving initially the north and west of the city, but with the potential to complete or link with existing modalities, will have to be assessed both in its own right and in terms of its complementarity.

While an initial integrated model at network level is unlikely to answer all questions raised, it seems evident, (given recent experiences with alternative modalities), that assessing the Metro's potential to have a positive impact on road usage and the 'greening' of Dublin transport, is a necessary step in the planning process.

**Please contact:**

John R Walsh

The Economic and Social Research Institute, Dublin

Tel: +353 1 8632054

E-mail: [John.Walsh@esri.ie](mailto:John.Walsh@esri.ie)

## Energy-Optimized Electrical Systems for Land Transport Using Batteries and Supercapacitors: TRANS-SUPERCAP

by Paul Borza, Ana Maria Puscas and Marius Carp

*The 'TRANS-SUPERCAP' project plans to optimize the energy use, operation, reliability and availability of locomotives and automobiles by redesigning the electric starting systems of the internal combustion engine. This is done using combinations of batteries and 'stacked'-type supercapacitors provided by new nanotechnology.*

It is known that energy storage and mobile energy sources are critical elements for powered systems. Existing energy storage devices do not satisfy all modern requirements, especially when a device must demonstrate high performance and be energy efficient. The TRANS-SUPERCAP national research project, currently under development at the 'Transilvania' University of Brasov, will demonstrate that a satisfactory compromise can be reached by combining energy sources (batteries), rapid-release storage devices (high voltage [9F/110V]

aqueous stacked supercapacitors) and an intelligent control system.

This project proposes the research and development of an, energy-efficient electric starting systems with a long lifespan. These will use a combination of battery and supercapacitors, adjusted according to the load, using power-switching devices controlled by an embedded system. This latter system will control the power flow transfer between the source and the load by monitoring and anticipating

the demand from the load side, in order to optimize the energy efficiency of the whole system. This implementation allows not only energy and material consumption but also environmental pollution to be reduced.

The project will work toward a deeper understanding of the transient phenomena occurring into the whole system, in energy and power sources, ICE (internal combustion engine), and also the DC starter motors. The project

will develop integrated model sources, an electric starter motor, ICE and control systems and also a methodology for system design which will permit its rapid adaptation to any type of vehicle.

Most vehicles currently use lead-acid (L-A) batteries as power supplies for starting their ICEs, after which the running of the ICE provides the electricity necessary for vehicles. The starting process is critical because it requires significant peaks of power from batteries. Assessing the damage caused by starting shocks is a difficult task. Thus, all the design methodologies for starting systems of vehicles take into account an over-dimensioning of the batteries. To protect and also to assure a reliable starting process, the designer over-dimensions the battery, that means they increase the battery capacity in order to assure the maximum current demanded by DC starting motor and at the same time try to prevent the deep discharge which would significantly reduce its lifetime.

Progress in nanotechnology has brought with it important improvements in supercapacitors, which are now better able to fulfill requirements related to maximum current, power and energy density. It therefore appears mandatory to introduce an energy management system developed for mobile applications that also assure the harmonization of the time constants between the different power supplies or storage devices.

Combined solutions involving L-A batteries and supercapacitors appear to be feasible and an optimum compromise in terms of energy economy, materials, size and cost (including maintenance

costs). While low-temperature starts are a problem for batteries, in the case of the combined solution, the battery will be protected and ICE starting will be significantly improved. By providing intelligent and adaptive switching of the electric starter motor between supercapacitor and battery, the characteristic response of the system can be optimized both in the starting phase and in the charging phase of the batteries.

In the specific case of locomotives, the most important requirements are the reliability and availability of the starting system, low weight, and the cost and fuel consumption. Our energy management system optimally satisfies all these necessities:

- the mass and volume of the power supply have been reduced by more than half
- the application does not need balancing resistors for component cells of high voltage supercapacitor
- this type of supercapacitors is 'stacked' with aqueous electrolyte (KOH) and doesn't generate poisonous gases during functioning
- the devices operate between  $-40^{\circ}\text{C}$  and  $+80^{\circ}\text{C}$ , maintaining a very low ESR (Equivalent Series Resistance) over the entire temperature range assuring a very high reliability of starting process
- the storage devices are compact and ecologically sound, with a very high dynamic stability (tested at sinus  $4\text{ g}(\text{ms}^{-2})$  mechanical vibration stress for more than 1000 hours with no damage); the devices accept more than 10 g acceleration shock without damage
- the system presents a high power density (by mass and volume).

The starting system described here has been successfully tested over a one-year period in collaboration with the Romanian Railways Company. The successful results of the tests, with implications for increased reliability and reduced costs, encouraged the application of stacked supercapacitors utilizing aqueous electrolyte to improve the starting systems of diesel locomotives and other diesel engine vehicles.

The energy management system which has been developed allows switching between the two energy sources (supercapacitors and batteries) to occur automatically, depending on the temperature and oil pressure within the ICE.

We are encouraged by these results, and are now working on developments such as dynamic retrieval of breaking energy on vehicles, mechatronic actuator systems, and active filters used to improve energy grid parameters. At the same time, energy sources endowed with intelligent controlled storage devices will lead to future architectural forms for energy sources, especially for mobile types. By embedding the control in each combined energy cell and developing the hierarchical architecture, the complexity of bidirectional energy transfer can be better mastered to give a direct improvement in energy efficiency.

**Please contact:**

**Paul Borza, Ana Maria Puscas and Marius Carp**  
Transilvania University of Brasov,  
Romania  
E-mail: [borzapn@unitbv.ro](mailto:borzapn@unitbv.ro),  
[ana\\_maria.puscas@yahoo.com](mailto:ana_maria.puscas@yahoo.com),  
[marius.carp@yahoo.com](mailto:marius.carp@yahoo.com)



*An electric starting system installed on locomotive. The system include two components: the locomotive driver console (left) and the embedded systems dedicated for the main subsystems. The picture on the right shows the box of supercapacitors and the afferent control systems linked to console by an Ethernet bus.*

# SensorWeb-Based Prototype for Air Quality Reporting Systems

by Katharina Schleidt and Denis Havlik

Two European research projects, SANY (Sensors Anywhere) and the Austrian INSPIRE CAFE prototype are currently testing the usability of the Open Geospatial Consortium (OGC) Sensor Web Enablement (SWE) suite for CAFE (Clean Air For Europe) and INSPIRE (Infrastructure for Spatial Information in the European Community), by developing a prototype air quality reporting system in accordance with the CAFE directive. Unlike the Web Feature Service, which excels at geographic features, the SWE services and encodings help to model the world from a sensor-centric view, with each observed value being associated with a geographic and temporal position, as well as the unit of measurement, data quality value, and process description.

The INSPIRE directive requires exchange of geospatial data relevant to the environment between public authorities, as well as provision to the research community and to the general public, according to international standards within the next decade. In addition, the Shared Environmental Information System (SEIS) foresees the acquisition and integration of environmental data from distributed sources across Europe for reporting and policy purposes as well as for provision of the information to the public.

Four INSPIRE CAFE prototype projects contracted by Joint Research Center are currently testing possible technical solutions for open standards-based INSPIRE networks suitable for air quality reporting

in accordance with the CAFE directive (Clean Air For Europe) in Austria, Poland, Slovakia and the United Kingdom.

CAFE will report annually on the following:

- air quality monitoring zones
- air quality monitoring stations
- validated air quality monitoring data
- threshold exceedances for zones and stations.

In addition, the CAFE directive requires access to the near real time air quality data for general public.

To date, INSPIRE has been driven by the Spatial Data Infrastructure community, relying on traditional OGC Web Feature Service (WFS) services for data

provision. Based on an analysis of the requirements of the CAFE directive, the Austrian development team realized that a much stronger focus on the measurements obtained at the monitoring sites would be required than can be served by WSF-based solutions.

In the meantime, the SANY Sensor Anywhere FP6 Integrated Project published the 'Sensor Service Architecture' (SensorSA) specifications. SensorSA advocates the use of the OGC Sensor Web Enablement (SWE) suite for accessing sensors and similar data sources. Unlike other OGC standards, which focus on the spatial aspects of the data, the SWE suite has been designed specifically to interact with sensor networks and allows explicit description and efficient handling of the sensor-related data, metadata and operations. In addition, SANY developed a number of services for processing and visualization of sensor data, including the 'Cascading SOS' service developed by Austrian Institute of Technology. Cascading SOS can extract the information from available SOS services and produce various indicators, including those required for CAFE reporting, on the fly. Finally, the SANY SP4 air quality demonstrator has already integrated some of the Austrian air quality data in a SensorSA/SWE-compliant network.

This led to the idea of basing the Austrian INSPIRE CAFE prototype on SANY technology. On the SANY side, the air quality use cases, data models and functionality were extended based on the INSPIRE-CAFE requirements. The Umweltbundesamt Austria, which is participating in both projects, provided the concrete requirements for the air quality reporting in accordance with the CAFE directive. These include

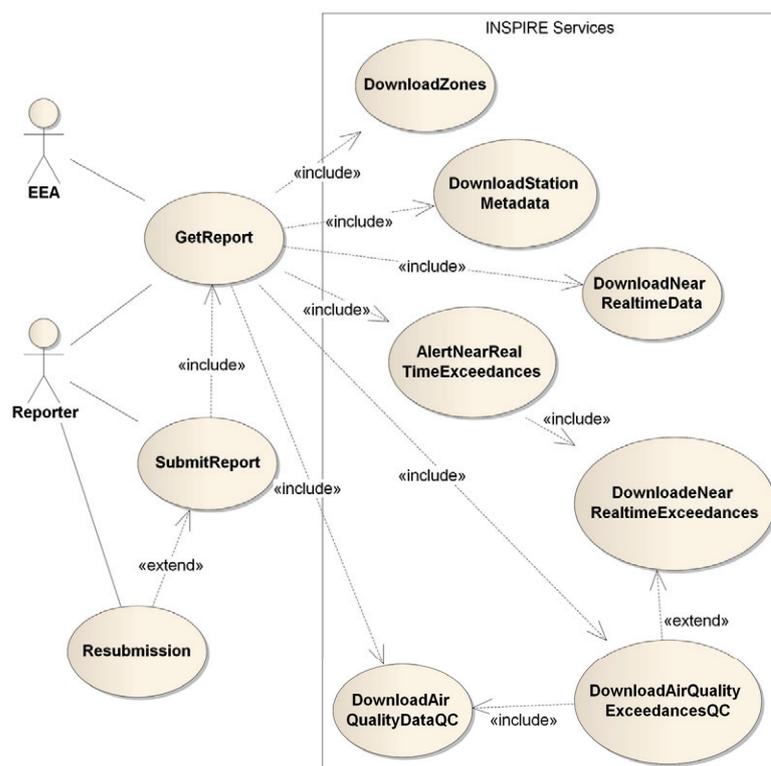


Figure 1: Main INSPIRE CAFE reporting use cases.

metadata and data according to the INSPIRE directive, as well as transformed and aggregated data as required by the CAFE directive.

Preliminary results of this work, which will be presented at the final SANY event, confirmed the superiority of OGC SWE-based solutions as compared to classical WFS services, not only for INSPIRE/CAFE affine modelling of the immission and emission

sensor data but also for the results of the data fusion, modelling and reporting services ('soft sensors'). In addition, the INSPIRE-compliant version of the SANY catalogue service illustrates that the INSPIRE-relevant meta-information can be harvested from SWE services.

All parties interested in the use of SensorSA and OGC SWE in the context of CAFE and INSPIRE are invited to

join the final SANY event and SP4 demonstration on November 19th in Linz. Participation in this event is free of charge, but the registration is required. Instructions for registration are available on the SANY Web site.

**Links:**

INSPIRE: <http://inspire.jrc.ec.europa.eu/>

JRC: <http://ec.europa.eu/dgs/jrc/>

OGC SWE:

<http://www.opengeospatial.org/projects/groups/sensorweb>

SANY IP: <http://sany-ip.eu>

SEIS:

<http://ec.europa.eu/environment/seis/>

SensorSA:

<http://www.sany-ip.eu/biblio/type/11>

**Please contact:**

Katharina Schleidt

Umweltbundesamt GmbH (Governmental Environmental Agency), Austria  
Tel: +43-(0)1-313 04/5363

E-mail:

[katharina.schleidt@umweltbundesamt.at](mailto:katharina.schleidt@umweltbundesamt.at)

Denis Havlik

Austrian Institute of Technology, Safety and Security Division (AARIT)

Tel: +43 50550 3157

E-mail: [denis.havlik@ait.ac.at](mailto:denis.havlik@ait.ac.at)

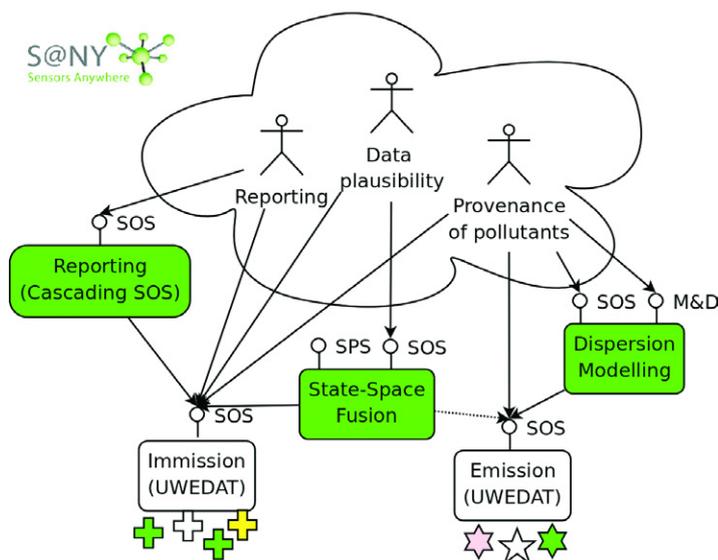


Figure 2: SANY air quality pilot (Linz) use cases and data provision services.

## New Technologies Provide Overview@aGlance at Large Music Festivals

by Preben Holst Mogensen and Marlene Nybro Thomsen

*Overview@aGlance is the name of a collaborative overview system that integrates a number of technologies to provide overview and support collaboration between emergency response teams at large events such as music festivals.*

The @aGlance system has just returned to Aarhus University from a beech wood near Skanderborg, Denmark, where it was trialled at the Danish music festival 'Skanderborg Festival 2009'. The festival site and its surroundings consisted of a forest with hilly terrain and narrow paths, making it an extremely challenging and thereby perfect setting for testing out this technology, which is intended to support emergency response personnel at geographically and organizationally distributed events.

Forty thousand attendees and ten thousand volunteer helpers and emergency

staff (police, security, local alarm centre, coordinators, stretcher teams etc) were gathered at the annual festival in the wood. The emergency staff tested @aGlance together with developers from the Computer Science Department at Aarhus University and The Alexandra Institute. This technology represents a big step towards making this festival safe and secure for visitors in the future.

Erik Pong Madsen, who has been responsible for security at the festival for 29 years, said, "The @aGlance system provides us the needed overview of our emergency response personnel, of the festival and its surroundings. In

the end it is a question of saving time and money – but it all comes down to saving human lives and ensuring a safe festival for our 50 000 guests."

The @aGlance system integrates well-known technologies such as GPS radios, mobile phones, remotely controlled video cameras, WiFi access points and monitors (large stationary and smaller portable), GIS data and 3D visualization. This provides emergency response personnel with a common and dynamic frame of reference, improving their overview of the festival. In particular, they:

- can see 'at a glance' what is happening at the festival (overview)

- can see where the other personnel are (location)
- can see what the other personnel see (collaboration)
- can choose their own or their colleagues' point of view and can see what is happening nearby (context).

The backbone of this system is an integrating 3D environment. It contains 3D models of the Skanderborg area, camping areas, festival site, stages, stalls, service centres, live video feed from the site, and tracking of stretcher teams, security guards and coordinators, to mention a few.

A comprehensive overview is provided by means of:

- integration of communication infrastructure (GPS and radio)
- visual communication (live video and pictures integrated in the 3D environment)
- activity indication (larger movements at the festival illustrated in the 3D environment)
- tracking emergency response resources and key personnel (via GPS, represented and located in the 3D environment)
- static and remotely controlled cameras
- local and central interaction with 3D environment using (i) handheld devices 'in the field', and (ii) centrally located stationary monitors at, for example, the local alarm centre or coordinators (see Figure 2).

The @aGlance system supports collaboration and overview, which are of paramount importance to emergency response personnel. A video browser shows all selectable video feeds from 24 video cameras centrally placed at the festival site, and tracked personnel are represented in the model, along with patients, place and position.

In the case of an emergency, the patient is pointed out by the local alarm centre and placed in the correct position in the 3D environment. The required personnel (eg doctors, stretcher teams and security teams) are notified and can see the same part of the 3D environment as the coordinators. For a given user this may include, for example, where the patient is, which way to go, where his own team is (GPS tracked) and where the doctor and other vital personnel are heading (also GPS tracked). The system also

supports visual communication as the users are able to draw ambulance roads, barriers or take pictures of the situation – which will then pop up in the correct location in the common 3D environment. In addition, in order to support crowd control and to prevent bottlenecks, the system analyses the video feeds to indicate activity, which is then also shown in the 3D environment.

The project is partly sponsored by the ICT-competence Centre ISIS Katrinebjerg. The experiment was a collaboration between the Computer Science Department, Aarhus University, the Alexandra Institute, the Skanderborg Festival Club and the software firm 43D. In the @aGlance project, Polycom and Sølund are also partners.

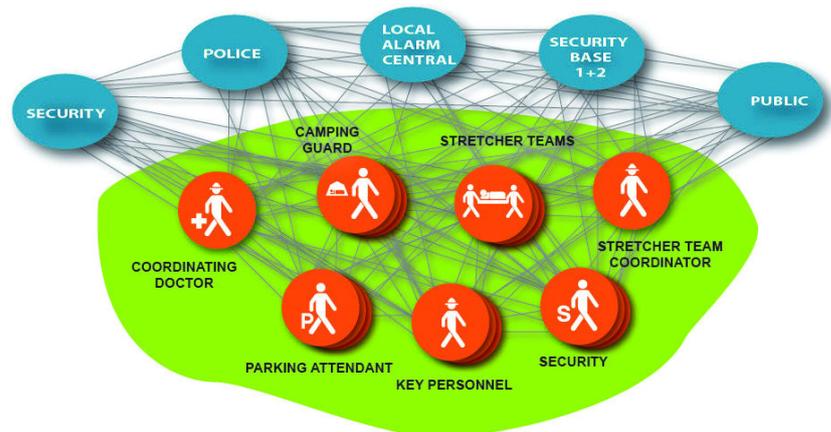


Figure 1: System overview.

In all, the Skanderborg experiment was a huge success. The festival visitors were in favour of the video cameras due to the safety they provided, and the festival staff used the system constantly to maintain an overview of what was happening on the site. The festival staff were happy to see their ideas from the iterative process based on user-centred design brought to life. The developers were happy to see it work – most of the time. In preparation for next year, they will work on further development and integration of innovative ideas.

**Link:**

<http://www.aglance.dk>

**Please contact:**

Preben Holst Mogensen  
Aarhus University, Denmark  
E-mail: [preben@cs.au.dk](mailto:preben@cs.au.dk)

Marlene Nybro Thomsen  
E-mail: [mthomsen@cs.au.dk](mailto:mthomsen@cs.au.dk)  
Aarhus University, Denmark

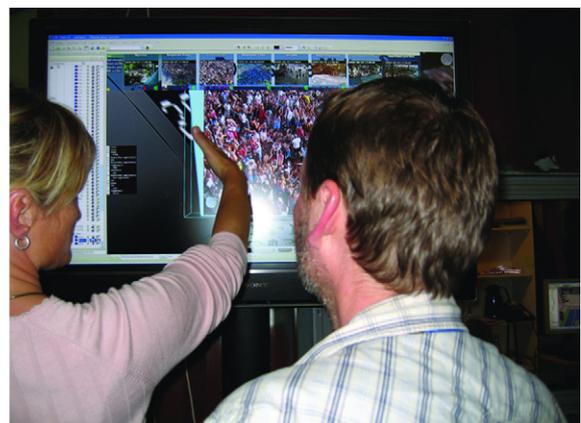


Figure 2: interaction with the 3D environment with handheld devices (left) and stationary monitors (right).

## Out of the Ether: Information Management for Archaeologists

by Martin Newman

*The Institute for Archaeologists (IfA) is a professional institute for the study and care of the historic environment in the United Kingdom. The Institute's annual conference was held in Torquay in England from the 7th to 9th April 2009 and saw a session to launch a new Information Management special interest group of the Institute. The new group is aimed at those working with historic environment data/information management, computing and informatics. This first event showcased a wide range of current projects and recent developments.*



*It's not just potsherds and bones any more. Information management is integral to modern archaeological practice.*

The session opened with a paper by Edmund Lee titled 'Everything We Know Informs Everything We Do': A Vision for Information Management. This set the scene for the papers that followed by examining the current state of historic environment information management in theoretical terms as well as looking at what needs to be undertaken to make information management central to good practice. There then followed a series of case studies. Jay Carver looked at multidisciplinary working for the Highways Agencies Cultural Heritage Management Plan which is drawing together datasets from a range of partners. Guy Hunt's paper concerned digital data creation on site, using a developer funded site as a test

bed for approaches and how theoretical approaches could be adapted to produce a hybrid system that worked in a practical environment. Mike Middleton and Susan Casey considered the impact of the INSPIRE directive and presented the preliminary findings of a study of the spatial depiction of heritage objects looking at spatial data quality and the current state of polygonisation in Scotland. David Thomas and Tom Pert talked about a major National Assembly for Wales supported initiative Csgliad y Bobl – the Peoples Collection, which is creating an online archive illustrating Welsh History using photographs, documents and film. The theme of online access continued with a sobering look at usability testing, with Cat Cload presenting a case study using the Heritage Gateway, a web portal for historic environment data managed by the National Monuments Record at English Heritage that uses web services to create interoperability between datasets from differing sources ([www.heritagegateway.org.uk](http://www.heritagegateway.org.uk)).

The final paper of the session also dealt with access via a portal. Dan Hull and Stuart Jeffrey presented a web services case study, HEIRNET the Historic Environment Information Network. The session also included the group's Annual General Meeting with the election of a committee. Versions of these presentations will be published in the first edition of the group's newsletter, and future events are planned including a joint meeting with the Forum on Information Standards in Heritage (FISH). It is hoped that the group will foster links between archaeologists involved in managing information and those working in information technology. Further information about the IfA Information Management Special Interest Group including membership is available on the IfA's website.

**Link:**  
<http://www.archaeologists.net>

**Please contact:**  
Martin Newman  
National Monuments Record,  
English Heritage, UK  
E-mail:  
[Martin.Newman@english-heritage.org.uk](mailto:Martin.Newman@english-heritage.org.uk)

## 13th European Conference on Digital Libraries

by Giannis Tsakonakos  
and Christos Papatheodorou

*The organization of the European Conference on Digital Libraries (ECDL) 2009 in Corfu from 27 September to 2 October 2009 signaled the second "visit" of ECDL to Greece, following ECDL 1998 in Heraklion, Crete. The theme of the conference was "Digital Societies", addressing the main issues that users and user communities confront within modern digital libraries, such as the creation and enrichment of information artifacts, sharing and distribution of information objects, retrieval and filtering mechanisms, enhancement of user interfaces to increase productivity, and digital preservation.*

128 full papers, 15 short papers and 38 posters and demos were submitted to the Conference. The final number of accepted papers was 28 in the full paper category, with an acceptance rate of 21.88%. There were two invited speeches: in the opening session Gary Marchionini, University of North Carolina, talked about "Digital Libraries as Phenotypes for Digital Societies", and on the final day Peter Buneman, University of Edinburgh, presented his thoughts on "Curated Databases".

This year, it was decided to introduce some novel features to the conference structure. The first feature was the proposal of four special plenary sessions which solicited focused high quality papers on the areas of Infrastructures, Services, Foundations and Content. For each of these areas, a separate call for papers was distributed to the research communities. The reviewing process for the special sessions was united with that for the main Call with an acceptance rate for these submissions of approximately 25%, resulting finally in two special sessions on Infrastructures and Services. The second innovative feature was the recreation of Posters and Demos in Second Life in order to digitally preserve this year's posters and demos. This effort was undertaken successfully by the Digital Libraries



*ECDL opening session.*

and Preservation Group, Virginia Polytechnic Institute and State University, USA and Information Systems Group, Instituto Superior Técnico, Lisbon, Portugal.

The Conference was accompanied by a very large number of satellite events. On Sunday 27 September a Doctoral Consortium and four tutorials were held. The Consortium consisted of presentations and discussions of the work of eleven Ph.D. students; the post-Consortium proceedings will be published by the Bulletin of the IEEE Technical Committee on Digital Libraries. The tutorials were on:

- Aggregation and reuse of digital objects metadata from distributed digital libraries
- Knowledge Organization Systems in Digital Libraries
- Designing user interfaces for interactive information retrieval systems & digital libraries
- Digital preservation: Logical and bit-stream preservation using Plato, EPrints and the Cloud.

Nine workshops were also organised on 1 and 2 October, following the main conference:

- Digital Curation in the Human Sciences
- Digital Libraries: Interoperability, Best Practices and Modelling Foundations
- Harvesting Metadata: Practices and Challenges
- 8th European Networked Knowledge Organisation Systems Workshop
- 2nd Workshop on Very Large Digital Libraries
- BooksOnline '09: 2nd Workshop on Research Advances in Large Digital Book Collections;
- Workshop on Exploring Musical Information Spaces
- 9th International Web Archiving Workshop
- 10th Cross-Language Evaluation Forum.

In addition numerous project meetings were held and three lectures on important topics of digital libraries were given by well-known experts to students of the International Master in Digital Library Learning programme (DILL, <http://dill.hio.no/>)

Digital Libraries is a very multidisciplinary domain and the more than 220 participants at the conference came from a wide range of domains. This number rose considerably for the workshops which were attended by nearly 300 people. Although the majority of attendees were from Europe, there was also a good contingent from North America and Asia plus a few people from Africa. Approximately 25% of the participants were graduate or PhD students.

During the ECDL Steering Committee meeting, there was much discussion on the future directions of the conference. One of the points made was that the inclusion of European in the name was limitative. It was agreed that the conference name should be changed to "Theory and Practice of Digital Libraries" (TPDL) with the 2011 conference in Berlin. ECDL 2010, which will be organized by the University of Glasgow, UK ([www.ecdl2010.org](http://www.ecdl2010.org)), will thus be the final version with the name of ECDL.

ECDL2009 was organized by the Laboratory on Digital Libraries and Electronic Publishing, Department of Archives and Library Sciences, Ionian University, Corfu, Greece. The General Chairs were Sarantos Kapidakis and Christos Papatheodorou and the Organizing Chair was Giannis Tsakonas, all from Ionian University. The Programme Chairs were Maristella Agosti, University of Padua, Italy, and Jose Borbinha, Technical University of Lisbon, Portugal.

The ECDL2009 proceedings are published by Springer in the Lecture Notes for Computer Science series. ECDL 2009 was sponsored by ERCIM.

**Link:** <http://www.ecdl2009.eu/>

**Please contact:**  
**Christos Papatheodorou, Giannis Tsakonas, Department of Archives and Library Sciences**  
 Ionian University, Greece.  
 E-mail: {papatheodor, gtsak}@ionio.gr

## Cross Language Evaluation Forum Celebrates Tenth Birthday

by Carol Peters

**The results of the tenth campaign of the Cross Language Evaluation Forum (CLEF) were presented and plans for CLEF 2010 were unveiled at the annual CLEF workshop, held this year in Corfu, Greece.**

The objective of the Cross Language Evaluation Forum (CLEF) is to promote research in the field of multilingual information access (MLIA) research and development. This is done through the organisation of annual evaluation campaigns offering tasks designed to test different aspects of mono- and cross-language information retrieval systems. The aim is to encourage the development of next generation multilingual multimodal IR systems.

The participation in the CLEF initiative has increased steadily over the years, growing from just 20 research groups in CLEF 2000 to more than 150 groups this year, mainly but not only from academia. Most of the participants in CLEF 2009 were from Europe but there was also a good contingent from North America and Asia plus a few from South America and Africa.

*Scenes from CLEF 2009 Workshop.*



### CLEF 2009 Tracks

CLEF 2009 offered eight main tracks designed to evaluate the performance of systems for:

- multilingual textual document retrieval (Ad Hoc)
- interactive cross-language retrieval (iCLEF)
- multiple language question answering (QA@CLEF)
- cross-language retrieval in image collections (ImageCLEF)
- multilingual information filtering (INFILE@CLEF)
- cross-language video retrieval (VideoCLEF)
- intellectual property (CLEF-IP)
  - New this year
- log file analysis (LogCLEF)
  - New this year.

An experimental pilot task was also offered:

- Grid Experiments (Grid@CLEF).

In addition, CLEF collaborated in the organisation of Morpho Challenge 2009, an activity of the Pascal Network of Excellence.

A main result of the CLEF campaigns is the creation of a number of valuable, reusable test collections consisting of data in many languages and diverse media (text, image, speech and video) which are made available for system benchmarking purposes.

### Workshop

As usual, this year's workshop was held in conjunction with the European

Conference on Digital Libraries. It was attended by 160 researchers and system developers, who presented their experiments and results in lively plenary, parallel, poster and breakout sessions. There were several invited talks. Noriko Kando, National Institute of Informatics Tokyo, reported on the "Evolution of NTCIR", an evaluation infrastructure testing Information Access technologies for Asian languages) and Jaap Kamps of the University of Amsterdam presented the main outcomes of a SIGIR workshop on the "Future of IR Evaluation". Donna Harman, US National Institute of Standards and Technology, in a concluding talk summed up what she felt were the main achievements of CLEF over these ten years of activity.

The presentations given at the CLEF 2009 Workshop and detailed reports on the experiments of CLEF 2009 and previous years can be found on the CLEF website.

### CLEF 2010 – Conference on Multilingual and Multimedia Information Access Evaluation

CLEF 2009 has represented an important milestone for the MLIA community. After ten years of activity focused on stimulating the development MLIA systems and functionality through the organisation increasingly complex evaluation tasks, it is now time to assess achievements and to identify priorities for the future. For this reason, it has been decided to change the format for next year. CLEF 2010 will take the form of an independent, peer-reviewed Conference organised in conjunction with a set of Evaluation Labs, each running experiments aimed at testing performance in MLIA-related areas.

The Conference will be held in Padua, Italy, September 2010, as a four day event: The first two days will consist of plenary sessions in which keynote speeches and peer-reviewed papers will be presented. The goals will be to explore current needs and practices for information access, study new evaluation metrics and methodologies, discuss new directions for future activities in the European multilingual /multimodal IR system evaluation context. In Days 3 and 4, the results of the Labs will be presented in full and half-day workshops.

CLEF 2008 and 2009 have been sponsored by the TrebleCLEF project:

Evaluation, Best Practices and Collaboration in the Multilingual Information Access domain. The first Calls for Proposals for the organisation of Evaluation Labs and the preliminary Call for Papers for the submission of scientific papers to the Conference will be posted on the TrebleCLEF website.

### Links:

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

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

TrebleCLEF: <http://www.trebleclef.eu>

### Please contact:

Carol Peters

ISTI-CNR, Italy

E-mail: [carol.peters@isti.cnr.it](mailto:carol.peters@isti.cnr.it)

## ACM Europe Launched

*On 8 October, the Association for Computing Machinery (ACM) highlighted its ACM Europe initiative aimed at recognizing and supporting European members and ACM activities in the region, during a special reception in Paris honouring achievements in European computer science.*

Hosted by ACM President, Wendy Hall and ACM Europe Council Chair Fabrizio Gagliardi, the reception brought together ACM Turing Award winners from Europe, European winners of other major ACM awards, and ACM Europe Council Members. The reception, which took place in conjunction with Informatic Europe's annual European Computer Science Summit (ECSS 2009), offered a showcase for ACM's effort to illuminate the role of computing in driving innovation as a top priority in a global environment.

ACM is the world's largest educational and scientific computing society, uniting computing educators, researchers and professionals to inspire dialogue, share resources and address the field's most pressing challenges. Its mission is to ensure a stronger collective voice for the profession through thought leadership, promotion of the highest standards and the recognition of technical excellence, supporting the professional growth of its members by



providing opportunities for life-long learning, career development, and professional networking.

ACM Europe is spearheaded by fifteen leading computer scientists from academia and industry, who have recently formed the ACM Europe Council, in order to expand ACM's high-quality technical activities, conferences, and services in the European region.

ACM President Professor Dame Wendy Hall said, "our goal is to share ACM's vast array of valued resources and services on a global scale. We want to discover the work and welcome the talent from all corners of the computing arena so that we are better positioned to appreciate the key issues and challenges within Europe's academic, research, and professional computing communities and respond accordingly. For us, ACM Europe is about seeing leading European computer scientists shape and enhance what ACM does in Europe and for Europe".

Today's ACM European contingent includes more than 15,000 members and over 100 chapters, as well as an ever-growing number of ACM-sponsored conferences and symposia. The ACM Europe Council will serve this growing constituency by increasing the number of chapters, particularly for students; expanding interest in nominations for the many ACM professional awards and distinguished member grades; and engaging ACM's Special Interest Groups to focus on Europe when planning conferences and major events.

Fabrizio Gagliardi, ACM Europe Council Chair and Director of External Research Programs for Microsoft Research Europe, hailed the intent of ACM's European aim of illuminating the role of computing in driving innovation in a global environment. "By strengthening ACM's ties in the region and raising awareness of its many benefits and resources with public and European decision-makers, we can play an active role in the critical technical, educational, and social issues that surround the computing community," he said.

ACM, which serves a global community of over 95,000, unites the world's computing educators, researchers and professionals to deliberate ideas that constitute the lifeblood of the global technical community and disseminates the fundamental discoveries in computing through the ACM Digital Library, the most comprehensive resource for



ACM President Wendy Hall.

exploring the accumulated knowledge, defining also curricula and accreditation standards for university computing programmes and working to strengthen the foundations of computing education at the pre-college level.

ACM Europe Council Members include Fabrizio Gagliardi, Director of External Research Programs, Microsoft Research Europe (Chair); Andrew McGettrick, University of Strathclyde, Scotland; Marc Shapiro, INRIA and LIP6, France; Thomas Hofmann, Google EMEA, Zurich, Switzerland; Gerhard Schimpf, Chair, German ACM Chapter, Pforzheim, Germany; Alexander Wolf, Department of Computing, Imperial College London, UK; Gabriele Kotsis, Johannes Kepler University of Linz, Austria; Jan van Leeuwen, Utrecht University, The Netherlands; Avi Mendelson, Microsoft Research, Israel; Michel Beaudouin-Lafon, Universite Paris-Sud, France; Burkhard Neidecker-Lutz, Research Division, SAP AG, Germany; Bertrand Meyer, ETH Zurich, Switzerland; Paul Spirakis, University of Patras and the Greek Computer Technologies Institute, Greece; Wendy Hall, University of Southampton, UK (ACM President); Mateo Valero, Technical University of Catalonia, Spain.

**More information:**

ACM Europe: <http://europe.acm.org>

ACM: [www.acm.org](http://www.acm.org)

## Second ENISA-FORTH Summer School on Network and Information Security

*The European Network and Information Security Agency (ENISA) and the Institute of Computer Science (ICS) of the Foundation for Research and Technology - Hellas (FORTH) have organized the 2nd ENISA-FORTH Summer School on Network and Information Security (NIS'09), in Heraklion, Crete, Greece, from 14-18 September 2009. This year's theme was "Privacy and Trust in a Networked World" with an exciting programme of invited lecturers that covered a range of topics extending beyond pure technological areas to economic, policy, and legal issues.*

Network and Information Security (NIS) has emerged as a fundamental aspect of Information and Communication Technologies (ICT) and its widespread adoption for improving productivity, learning and leisure. While creating new opportunities for growth in European economy and for improving quality of life for its citizens, constant advances in ICT pose new challenges to NIS, requiring a high-level of alertness, solid understanding of technology and trends, and continuous adjustment of strategic options. Therefore, raising awareness and understanding on the issues involved in NIS is of paramount importance. In this perspective ENISA and FORTH have jointly taken the initiative to set up and support this Summer School. The Summer School aims at providing a forum for experts in Information Security, policy makers from EU Member States and EU Institutions, decision makers from the industry, as well as members of the research and academic community, to interact on cutting-edge and ground breaking topics in Network and Information Security.

The 3rd NIS Summer School on "Privacy and Security in the Future Internet", co-organized by ENISA and FORTH, will be held between 13-17 September 2010 in Heraklion, Crete, Greece. The "Future Internet" promises an exciting world: new services, new infrastructures, and new capabilities at

all levels. Devices that will automatically exchange information to facilitate users, services that take into account information from different and multiple sources, protocols and systems that are able to handle complex interactions. At the same time, however, concerns about privacy and security increase for individuals, organizations, and the society in general. Where should responsibility be placed and how should solutions be enforced and verified in a world of complex infrastructures and services? The 3rd Summer School on Network and Information Security (NIS'10) will cover topics that address technical, legal, and policy issues in this emerging world.

**More information:**

<http://www.nis-summer-school.eu>

**Please contact:**

Demosthenes Ikonomou

ENISA, Greece

E-mail:

[Demosthenes.ikonomou@enisa.europa.eu](mailto:Demosthenes.ikonomou@enisa.europa.eu)

Angelos Bilas

FORTH-ICS, Greece

E-mail: [bilas@csd.uoc.gr](mailto:bilas@csd.uoc.gr)

## Excitement from the ITU TELECOM WORLD 2009 Conference

by Harry Rudin

*These days, the air is typically full of discouraging economic news. In contrast, the atmosphere at the ITU TELECOM WORLD 2009 Conference in Geneva, 5 - 9 October, 2009, was up-beat and rippling with energy and excitement. Relevant to this issue of ERCIM News, there was considerable interest in Green ICT.*

Compared with most other branches, the Information and Communication Technology (ICT) industry is doing well. The resultant enthusiasm was very much in evidence at the International Telecommunications Union (ITU) TELECOM WORLD 2009 conference. At the conference, the ITU released several reports; here are some observations taken from one of them, "The World in 2009 - ICT Facts and Figures":

- Mobile growth is continuing unabated, with global mobile subscriptions expected to reach 4.6 billion by the end of this year, and mobile broadband subscriptions to top 600 million in 2009, having overtaken fixed broadband subscribers in 2008.
- More than a quarter of the world's population is online and using the Internet, also as of 2009. Ever-increasing numbers of users are opting for high-speed Internet access, with fixed broadband subscriber numbers more than tripling from 150 million in 2004 to an estimated 500 million by the end of 2009.
- ITU estimates show that three quarters of households now own a television set and over a quarter of people globally – some 1.9 billion – now have access to a computer at home. This demonstrates the huge market potential in developing countries, where TV penetration is already high, for converged devices, as the mobile, television and Internet worlds collide.

A key question is what to do about the current general economic crisis. In another report released, "Confronting the Crisis: ICT Stimulus Plans for Economic Growth," it is convincingly argued that relatively small investments in ICT result in substantial increases in a country's gross domestic product.

One conference session dealt with ICT stimulus stories from around the world. The world not only has economic problems - there was a widespread feeling that ICT will help with other problems such as making the provision of health services more efficient and helping to relieve the world's environmental problems through energy conservation and perhaps even climate control.

One of the sessions on green ICT dealt with the cataloging of different approaches for saving the energy required by ICT. Another session dealt with applications of ICT such as in smart homes, smart appliances, smart transportation, and smart energy grids.

Of course there are also problems resulting from ICT such as child protection in cyberspace, protection of property rights and even the danger of war in cyberspace. These topics were also discussed at length.

Overall, though, the general feeling at TELECOM 2009 is one of great optimism and the belief, for example, that ICT will be a major contributor to increasing the wellbeing in developing countries.

**Links:**

<http://www.itu.int/WORLD2009/>

[http://www.itu.int/ITU-](http://www.itu.int/ITU-D/ict/material/Telecom09_flyer.pdf)

[D/ict/material/Telecom09\\_flyer.pdf](http://www.itu.int/ITU-D/ict/material/Telecom09_flyer.pdf)

<http://www.itu.int/crisis2009>



## Celebration of Ten Years W3C Greece Office

*In the context of the 10-year long presence of the World Wide Web Consortium (W3C) in Greece, the W3C Greece Office held an event on September 16th, 2009 in Heraklion, Crete, at ICS-FORTH, where the office is hosted. The W3C Greece Office, which is among the first five offices to join the World Wide Web Consortium, shares the consortium's goals and vision and contributes towards the improvement and participation of the Greek community in the evolution of the World Wide Web.*

The celebration event took place in the context of the ENISA-FORTH Summer School, co-organized by the European Network and Information Security Agency (ENISA) and FORTH. The goal was to strengthen the ties between the W3C Members in Greece and their acquaintance with the managerial and research staff of W3C, FORTH and ENISA, as well as to exchange views on current, crucial matters regarding the World Wide Web. The talks given at the celebration covered a broad range of subjects ranging from effective content recommendation in social sites to Web security.

The introductory talk was given by Klaus Birkenbihl, coordinator of W3C's International Offices Program, who gave a brief history of W3C and discussed its most prominent technologies, such as HTML, XML and RDF that have affected the course of development of the Web.

Dr. Sihem Amer-Yahia, Senior Research Scientist at Yahoo! Labs, discussed information presentation of (possibly large) ranked datasets in two contexts: recommendations in social content sites and online search of structured datasets.

Dr. Giorgos Flouris, Research and Development Engineer at the Institute of Computer Science of FORTH, presented work on detecting high level changes for Semantic Web Data. He argued that dynamic ontologies are a key technology for the Semantic Web, and discussed an approach for an 'a posteriori' detection of ontology changes.

Finally, Dr Sotiris Ioannidis, Associate Researcher at the Institute of Computer Science of FORTH, discussed typical vulnerabilities attackers use to compromise Web systems and services and presented state of the art methods for tackling these vulnerabilities.

**Links:**

<http://www.w3c.gr/>  
<http://www.w3.org>

**Please contact:**

Eleni Orphanoudaki  
 Tel.: +30 2810 391702  
 E-mail: [eleni@ics.forth.gr](mailto:eleni@ics.forth.gr)

Irini Fundulaki

Head and Coordinator of the Greek  
 W3C Office  
 Tel.: +30 2810 391725  
 E-mail: [fundul@ics.forth.gr](mailto:fundul@ics.forth.gr)



CALL FOR PARTICIPATION

## Privacy on the Web: W3C Organizes Workshop on Access Control Application Scenarios

Luxembourg, 17-18 November 2009

W3C invites people to participate in a Workshop on Access Control Application Scenarios on 17-18 November 2009 in Luxembourg. This workshop is intended to explore evolving application scenarios for access control technologies, such as XACML. Results from a number of recent European research projects in the grid, cloud computing, and privacy areas show overlapping use cases for these technologies that extend beyond classical intra-enterprise applications. The Workshop, co-financed by the European Commission 7th framework program via the PrimeLife project, is free of charge and open to anyone, subject to review of their statement of interest and space availability. Position papers are due 23 October.

**More information:**

[http://www.w3.org/2009/policy-  
ws/cfp.html](http://www.w3.org/2009/policy-<br/>ws/cfp.html)  
 Privacy Activity:  
<http://www.w3.org/Privacy/>

CALL FOR PAPERS

## 40th International Symposium on Multiple-Valued Logic

Barcelona, Spain, 26-28 May 2010

The Multiple-Valued Logic Technical Committee of the IEEE Computer Society will hold its 40th annual symposium on 26-28 2010 in Casa Convalescència, Barcelona, Spain. The event is sponsored by the IEEE Computer Society, and is organized by the Artificial Intelligence Research Institute of the Spanish National Research Council (IIIA-CSIC), the University of Barcelona, the Autonomous University of Barcelona, and the University of Lleida.

You are invited to submit an original paper, survey or tutorial paper on any subject in the area of multiple-valued logic, including but not limited to:

Algebra and Formal Aspects, ATPG and SAT, Automatic Reasoning, Circuit/Device Implementation, Communication Systems, Computer Arithmetic, Data Mining, Fuzzy Systems and Soft Computing, Image Processing, Logic Design and Switching Theory, Logic Programming, Machine Learning and Robotics, Mathematical Fuzzy Logic, Nano Technology, Philosophical Aspects, Quantum Computing, Signal Processing, Spectral Techniques, Verification.

Authors should submit papers by 1 November 2009.

**Invited speakers:**

- Joao Marques-Silva, University College Dublin, Ireland
- Claudio Moraga, European Centre for Soft Computing, Spain
- Daniele Mundici, University of Florence, Italy.

**More information:**

[http://www2.iiia.csic.es/conferences/  
ismvl2010/](http://www2.iiia.csic.es/conferences/<br/>ismvl2010/)

## Events sponsored by ERCIM in 2010

ERCIM sponsors three conferences in 2010:

- The 35th International Symposium on Mathematical Foundations of Computer Science, hosted by the Faculty of Informatics, Masaryk University in Brno, Czech Republic, 23-27 August 2010  
<http://mfcs12010.fi.muni.cz/mfcs>
- The 11th European Conference on Computer Vision (ECCV 2010), hosted by FORTH, Crete, Greece 5-11 September 2010  
<http://www.ics.forth.gr/eccv2010/intro.php>
- SAFECOMP 2010 - 29th International Conference on Computer Safety, Reliability and Security, Vienna, Austria, 14-17 September 2010  
<http://www.ocg.at/safecomp2010.html>; <http://www.safecomp.org>

CALL FOR PARTICIPATION

## FMICS 2009 - 14th Intl. ERCIM Workshop on Formal Methods for Industrial Critical Systems

Eindhoven, The Netherlands,  
2-3 November 2009

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, these workshops are intended to bring together scientists and practitioners who are active in the area of formal methods and interested in exchanging their experiences in the industrial usage of these methods. These workshops also strive to promote research and development for the improvement of formal methods and tools for industrial applications.

### Invited Speakers

This year, FMICS will feature four outstanding invited speakers - two outstanding scientists and two prominent industrialists working in top companies with an emphasis on formal methods for critical systems :

- Dino Distefano, Queen Mary, Univ. London, UK: "Attacking Large Industrial Code with Bi-Abductive Inference"
- Diego Latella, ISTI-CNR, Italy: "On a Uniform Framework for the Definition of Stochastic Process Languages"
- Thierry Lecomte, ClearSy, France: "Applying a Formal Method in Industry: a 15-year trajectory"
- Ken McMillan, Cadence, USA: "What's in common between Test, Model checking, and Decision Procedures?"

### Accepted Papers

- J. B. Almeida, M. Barbosa, J. Sousa Pinto and B. Vieira: 'Correctness with respect to reference implementations'
- D. Delmas, E. Goubault, S. Putot, J. Souyris, K. Tekkal and F. Védrine: 'Towards an industrial use of FLUCTUAT on safety-critical avionics software'

- J de Dios and R. Pena: 'A Certified Implementation on top of the Java Virtual Machine'
- S. Evangelista and L. M. Kristensen: 'Dynamic State Space Partitioning for External and Distributed Model Checking'
- A. Goodloe and C. Munoz: 'Compositional Verification of a Communication Protocol for a Remotely Operated Vehicle'
- J. Mariño, A. Herranz, M. Carro and J. J. Moreno-Navarro: 'Formal modeling of concurrent systems with shared resources'
- P. Parizek and T. Kalibera: 'Platform-Specific Restrictions on Concurrency in Model Checking of Java Programs'
- M. Raffelsieper, M. Reza Mousavi, J.-W. Roorda, C. Strolenberg and H. Zantema: 'Formal Analysis of Non-Determinism in Verilog Cell Library Simulation Models'
- E. Schierboom, A. Tamalet, H. Tews, M. van Eekelen and S. Smetsers: 'Preemption Abstraction: a Lightweight Approach to Modelling Concurrency'
- K. J. Turner and K. Leai Larry Tan: 'A Rigorous Methodology for Composing Services'.

### Accepted Posters

- A. Ferrari, A. Fantechi, S. Bacherini and N. Zingoni: 'Formal Development for Railway Signaling Using Commercial Tools'
- N. Izerrouken, M. Pantel, X. Thiroux and O. Ssi yan kai: 'Integrated Formal Approach for Qualified Critical Embedded Code Generator'
- L. Ladenberger, J. Bendisposto and M. Leuschel: 'Visualizing Event-B models with BMotionStudio'
- A. Mathijssen, Y. S. Usenko and D. Bosnacki: 'Behavioural Analysis of an I2C Linux Driver'
- W. Mostowski, E. Poll, J. Schmaltz, J. Tretmans and R. Wichers Schreur: 'Model-Based Testing of Electronic Passports'
- L. Panizo, M. M. Gallardo, P. Merino and A. Linares: 'Developing a decision support tool for Dam management with SPIN'

FMICS 2009 is part of the first Formal Methods Week (FMweek), which will bring together a choice of events in the area.

For the latest information on FMweek, see <http://www.win.tue.nl/fmweek>.

### Organisation

- PC co-Chairs: Maria Alpuente (T. U. Valencia, Spain) and Byron Cook (Microsoft, UK)
- Workshop Chair: Christophe Joubert (T. U. Valencia, Spain).

### More information:

<http://users.dsic.upv.es/workshops/fmics2009/>

CALL FOR PARTICIPATION

## MLIA Technology Transfer Day

Berlin, Germany, 8 December 2009

The aim of the MLIA Technology Transfer Day is to facilitate a two-way communication of research priorities, advances and results between researchers, software developers and users.

The event will begin with the presentation of a set of Best Practice recommendations in the areas of MLIA System Development and Search Assistance, Test Collection Creation, Evaluation Methodologies and Language Processing Technologies.

Key speakers from the business and application communities will present their experiences, requirements and problems with respect to Multilingual Information Access.

There will also be a demo session and a panel discussion on the current state of the art, focusing on those areas where the application communities have problems in identifying the best solutions for their particular requirements.

The MLIA Technology Day will be held at the World Alliance Center in Berlin. Join us for an in-depth discussion on key issues in the Multilingual Information Access domain. Participation is free of charge but places are limited. Register now at the URL given below. The event is promoted by the TrebleCLEF project.

### More information:

<http://celct.isti.cnr.it/MLIA-Day/>

Sponsored by ERCIM

## SAFECOMP 2010 - The 29th International Conference on Computer Safety, Reliability and Security

Vienna, Austria, 14-17 September 2010

Since it was established in 1979, SAFECOMP has contributed to the progress of the state-of-the-art in dependable application of computers in safety-related and safety-critical systems. SAFECOMP is an annual event covering the state-of-the-art, experience and new trends in the areas of safety, security and reliability of critical computer applications.

The Key Theme of Safecomp 2010 is Critical Embedded Systems Challenges and Risks. The emphasis of this event is to take a look at critical embedded systems which are already almost

omnipresent, communicating and cooperating, interacting with each other, humans and environment. The primary issue is to cope with complexity and new paradigms of failure modes and resource management, due to shrinking feature size, multi-core systems on chip and management of multiple variants while maintaining dependability properties and robustness of systems.

The topic includes purely scientific/technical as well as societal aspects. It concerns (explicitly used or hidden) devices, services, infrastructures, machines, transport systems, robots etc. It also involves raising awareness for rare circumstances under which, because of an unlucky combination of conditions, a normally non-critical system may endanger life, as may be the case when relying too much on past correct operation. Therefore, a holistic view is required. The conference will cover research in all related areas, industrial experience and practice, reports from interesting R&D projects, studies, standardization issues, assessment, evaluation and certification of systems, tools

and utilities. Different application domains as well as generic, cross domain issues may be covered.

Papers are invited in application and industrial sectors as well as research areas.

### Important dates

- Abstract submission: 8 February 2010
- Full paper submission: 8 March 2010
- Tutorial/Workshop proposal submission: 6 April 2010
- Notification of acceptance: 10 May 2010

Accepted papers will appear in the conference proceedings published by Springer-Verlag in the series Lecture Notes in Computer Science (LNCS).

Extensions of the best papers will be considered for publication in a Special Issue of the International Journal on Reliability Engineering and System Safety (RESS) published by Elsevier.

### More information:

<http://www.ocg.at/safecomp2010.html>

## ERCIM Endorses “Enabling Open Scholarship”

As a signatory of the “Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities”, ERCIM endorses “Enabling Open Scholarship”, an organisation with the mission to promote open access, open education, open science and open innovation.

Enabling Open Scholarship (EOS) is an organisation for universities and research institutions worldwide. The organisation is both an information service and a forum for raising and discussing issues around the mission of modern universities and research institutions, particularly with regard to the creation, dissemination and preservation of research findings. The aim of EOS is to further the opening up of scholarship and research that we are now seeing through the growing open access, open data, open education, open science and open innovation movements. These, and other, 'open' approaches to scholarship are changing the way research and learning are done and there are profound implications for universities and research institutions. EOS has been established to help guide developments and to assist others in understanding the issues and their implications.

Enabling Open Scholarship provides the higher education and research sectors around the world with information on developments and with advice and guidance on implementing policies and processes that encourage the opening up of scholarship. It also provides a forum for discussion and debate amongst its members and will be taking that discussion into the wider community.

### Membership

EOS membership is for senior institutional managers who have an interest in, and wish to help develop thinking on, strategies for promoting open scholarship to the academy as a whole and to society at large.

The EOS website is a resource open to all. It provides background information, data and guidance material on open scholarship-related issues. There is an area of the site that is accessible to members only where members can find announcements, news and discussions.

### What does EOS offer?

EOS offers an outreach service to universities and research institutes - whether members or not - that need help, advice, guidance or information on open scholarship issues. EOS does this through their Web site resource and also by providing information on an individual basis to institutions that need it.

The EOS board is composed of people who have personally instigated the kinds of changes in their own institutions that herald the benefits of the open scholarly communication system of the future. This expertise is available for others to tap into. Institutional managers who would like guidance or advice on developing policies and procedures can request help from EOS in developing policy and procedures in their own institution.

### More information:

<http://www.openscholarship.org>

## UK Government Moves to Put Data on the Web

The Office of the Prime Minister in the UK announced in June 2009 that Tim Berners-Lee will “help drive opening of access to Government data on the Web over the coming months.” The announcement is an important step in helping to fulfill the vision for a Web of Linked Open Data built on W3C's open Semantic Web standards, exposed by Berners-Lee in his TED 2009 talk ([http://www.ted.com/index.php/talks/tim\\_berniers\\_lee\\_on\\_the\\_next\\_web.html](http://www.ted.com/index.php/talks/tim_berniers_lee_on_the_next_web.html)). “Government data - the people's data - is an important component to the larger Linked Open Data movement,” said Berners-Lee. “I look forward to working with multiple government agencies and local enthusiasts to help early adopters bring their data to the bigger picture.” In April, Berners-Lee engaged similarly with the US government offering to help them join the “rapidly growing Linked Open Data cloud, to which US recovery data will be a welcome addition.” W3C's own eGovernment Interest Group has also been actively building an international network of support to work with governments on issues of transparency, accountability, and efficiency through open data.

More about W3C's eGovernment activities at:  
<http://www.w3.org/2007/eGov/>

## 40 Years Informatics Curricula in Austria

In 1969 the first official informatics curricula were started in Austria. This anniversary was celebrated at the Johannes Kepler University Linz in April 2009. The Austrian universities celebrated this event together with 300 attendees. In 1969, university curricula were initiated via law and the Johannes Kepler University Linz began with the first official computer science curriculum in October 1969, soon followed by other Austrian universities. In spring 1971 a large workshop was hosted by the Ministry of Science in order to define and design computer science courses: The results were collected in a 180-strong proceeding volume (Stetter, H. and Weinmann A.: Informatik - Aspekte und Studienmodelle - Symposium zur Vorbereitung einer neuen Studienrichtung in Österreich, Publication Series of the Technical University Wien, Springer Vienna-New York,

1971) and provide today interesting reading about the visions and plans of that time.

The celebration included a retrospective keynote by Christiane Floyd, University Hamburg, on the changes to informatics over the years and a future oriented keynote by Johann Eder, University Klagenfurt, on ‘Grand Challenges in Informatics’. Additionally four pioneers from academia, four visionaries from academia, and six high ranking industrial specialists were interviewed on stage as to the history, status and future of computer science.

A Festschrift (in German) containing both the material from the celebration and additional historical material on the development of Informatics Curricula will be available in fall 2009 from the Austrian Computer Society at <http://www.ocg.at>.

## ERCIM Cor Baayen Award Winner Named Top Young Innovator by MIT Technology Review



Adam Dunkels, senior scientist at SICS, Sweden, has been recognized by MIT Technology Review magazine as one of the world's top innovators under the age of 35 for his work on Internet-connectivity for embedded systems and wireless sensors. Selected from more than 300 nominees by a panel of expert judges and the editorial staff of Technology Review, the TR35 is an elite group of accomplished young innovators who exemplify the spirit of innovation.

Adam Dunkels is known for his minimal software that allows any device to be connected to the Internet. His software is used by hundreds of companies including Cisco, BMW, NASA, Hewlett-Packard, General Electric, and ABB, in such diverse applications as air planes, car engines, satellites, and TV set top boxes. In 2008, he received numerous awards for his work, including the Xerox Chester Carlson prize, the ACM EuroSys Roger Needham award, and the ERCIM Cor Baayen award. Adam Dunkels is one of the founders of the IPSO Alliance, which TIME Magazine ranked as one of the most important innovations of 2008.

Additional information about past and present TR35 winners and judges is available at [www.technologyreview.com/tr35/](http://www.technologyreview.com/tr35/). View winner Adam Dunkels in the TR35 Listing.



*Christiane Floyd and Johann Eder.*



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.



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



Irish Universities Association  
c/o School of Computing, Dublin City University  
Glasnevin, Dublin 9, Ireland  
<http://ercim.computing.dcu.ie/>



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



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



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



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



Centrum Wiskunde & Informatica

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



Universitas Varsoviensis  
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Universitas Wroclaviensis

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/>



Danish Research Association for Informatics and Mathematics  
c/o Aalborg University,  
Selma Lagerlöfs Vej 300, 9220 Aalborg East, Denmark  
<http://www.danaim.dk/>



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/>



Fonds National de la  
Recherche Luxembourg

Fonds National de la Recherche  
6, rue Antoine de Saint-Exupéry, B.P. 1777  
L-1017 Luxembourg-Kirchberg  
<http://www.fnrl.lu/>



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/>



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

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



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



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



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



Fraunhofer ICT Group  
Friedrichstr. 60  
10117 Berlin, Germany  
<http://www.iuk.fraunhofer.de/>



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



INRIA

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



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