cs.au.dk

MAGAZINE ABOUT THE DEPARTMENT OF **COMPUTER SCIENCE** AT AARHUS UNIVERSITY

content

"The children go totally wild and romp around when they get the concept. The keywords for the prototype are precisely play and togetherness."

"An experience seems more current and tangible when the whole body is in play"

"We decided that it was a case of all or nothing and that it needed to be fully tested."

Publisher Department of Computer Science, Aarhus Universitet / **Editorial staff** Arne Vollertsen, Marie Rørdam Fenger, Peter Gammelby, Kurt Jensen, Søren Poulsen, Jesper Wolff Olsen, Simon Tjell / **Editorial assistants** Bjarke Rosenbeck, Marianne Dammand Iversen / **Writers** Stig Andersen, Peter Gammelby, Bjarke Rosenbeck, Arne Vollersen, Marie Rørdam Fenger, Maria Øster, Ann Eg Mølhave, Marianne Dammand Iversen / **Photographers** Jesper Voldgaard, Sara Kangas / **Layout** Hanne Kolding / **Print** PrinfoDjurs

Department of Computer Science / Aabogade 34 / DK-8200 Århus C / tel.: +45 8942 5600 / fax: +45 8942 5601 / e-mail: cs@cs.au.dk / cs.au.dk

COLLABORATION

"Speed is not everything. What use is it to have a super smart algorithm to help a computer solve problems at lightning speed, if a sudden fault in the memory causes the computer to crash?"

"Photoshop is a large and complex program and normal users do not need all the possibilities provided by the program, so why should they take up space?"

COMPUTER SCIENTISTS IN WORK

THE 9 RESEARCH GROUPS

me and my prototype

THE INTERACTIVE BEANBAG

TEXT: PETER GAMMELBY / PHOTO: SARA KANGAS

MARIANNE GRAVES PETERSEN is a researcher at the Center for Interactive Spaces and works on the integration of IT into physical surroundings. As a project manager she has been involved in the creation of a large yellow beanbag that is used interactively to display images.

What makes the prototype interesting?
"It's exciting that we are thinking of IT in new and different contexts. IT is becoming an increasingly important part of our everyday lives, but technology often makes people passive. The beanbag can be used to take and display images depending on the movement that are made. The prototype demonstrates that IT can actually promote physical activity.

How has the development of the prototype gone?
"It has been an educational and exciting process. We have had some funny experiences when trying out the beanbag. The children go totally wild and romp around when they get the concept. The keywords for the prototype are play and togetherness, which hopefully become a greater part of IT in the future.

Be inspired by other exciting projects in 'Interactive Spaces' on page 28

POSITIONING OF PHONES

In Autumn 2008 **MIKKEL BAUN KJÆRGAARD** defended his PhD thesis, made in collaboration with Kirk Telecom. Mikkel has developed a prototype that is able to determine the position of wireless indoor devices.

Who will benefit from your prototype?
"The prototype can, for example, be used by prison personnel. If they get into a conflict situation they can summon a colleague who, with the aid of the positioning technology, will be able to see where in the building the problem has occurred. The telephones are fitted with an alarm button and the information about the alarm displayed on a map or sent as a text.

What have been the benefits of your work on this prototype?
"The creation of a prototype instead of just simulating parts of the system has inspired us to tackle a number of problem areas that we otherwise may not have discovered as important. By means of simulation it is easy to make assumptions that do not fit in with reality.

TEXT: MARIANNE DAMMAND / PHOTO: JESPER VOLDGAARD

Read more about the research group 'Modelling and Validation of Distributed Systems' on page 86

INFOGALLERY FOR LIBRARIES

BALASUTHAS SUNDARARAJAH is in charge of the InfoGallery at the Alexandra Institute. The InfoGallery is a new medium that makes digital content visible in physical space.

What makes the prototype interesting?
"Information is increasingly becoming digital, however the material is not visible in libraries. The InfoGallery will make this digital material available in physical space with a graphical expression that is exciting and has an air of adventure. However, the newest innovation is the fact that the screens are interactive, which will allow borrowers to investigate the content in greater detail.

How has it been to work on the prototype?
"It has been exciting to see how the prototype has developed from start up till now, but actually we can't call it a prototype any longer, as the product is already in place in a number of libraries. Personally, I have progressed from being a computer scientist to having great responsibility for the commercial development of the InfoGallery. It has really been an exciting process, which is still far from being complete.

TEXT: PETER GAMMELBY / PHOTO: SARA KANGAS

Read more about the development of InfoGallery into an economically sustainable product on page 50

InfoGallery has its origins in the research group 'Human Computer Interaction', of which you can read more on page 82

MOBILE IT SECURITY

TEXT: ANN EG MØLHAVE / PHOTO: JESPER VOLDGAARD

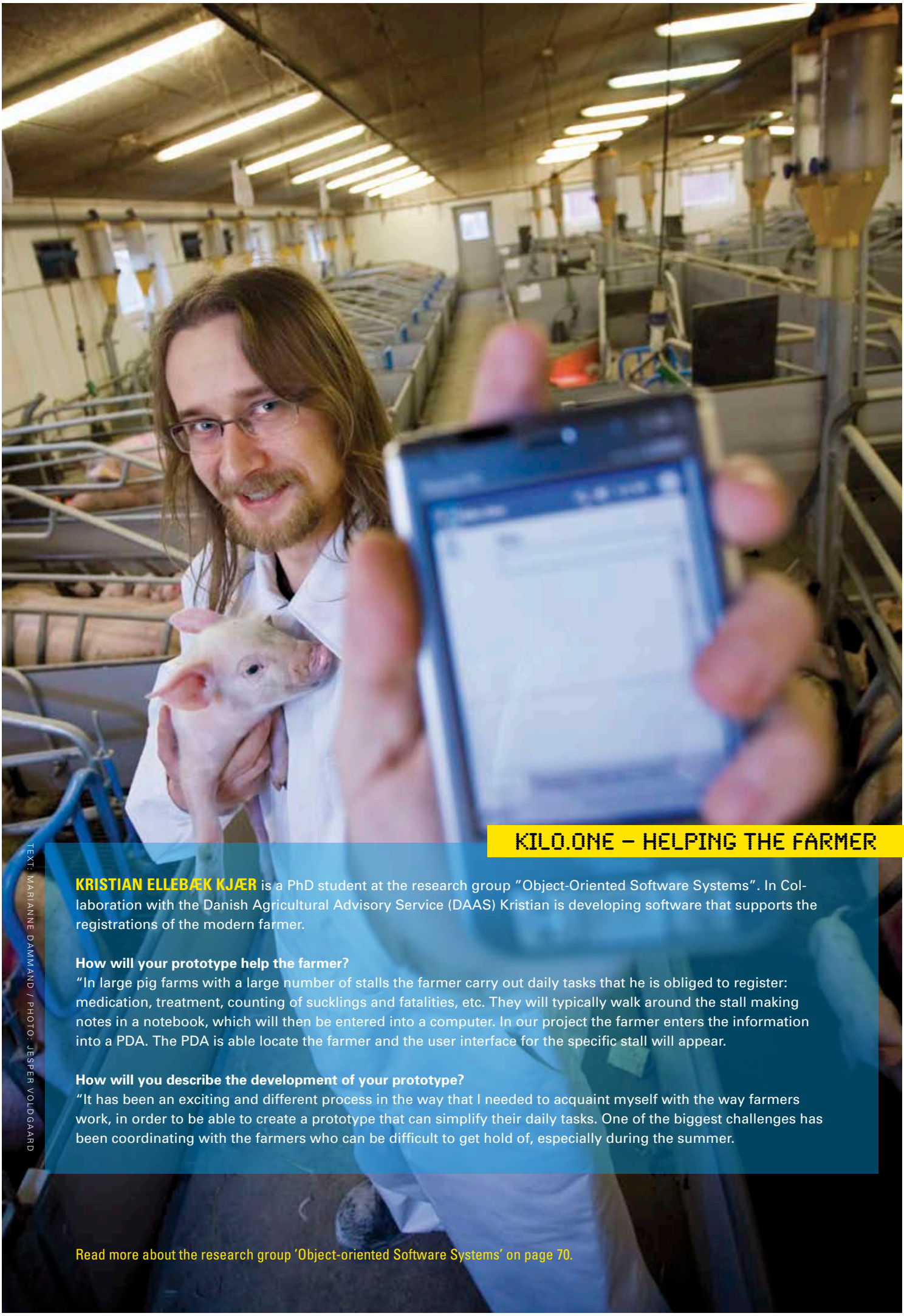
NIELS MATHIASEN is affiliated to the research group Human-Computer Interaction (HCI) as a PhD student. In the research project IT Security for Citizens, the HCI group is working with the Cryptology & Security group to create a more flexible digital signature than the one that is currently available.

What are the capabilities of your prototype?
"Our prototype makes it possible to bring along your digital signature when you are travelling and need to sign something. All that is required is your mobile phone and access to the Internet. We would like to roll the prototype out into areas that are not solely concerned with money. If we only conduct research into security in relation to money transfers, we will miss all of the other areas in which digital signatures could also be of benefit.

What has been the greatest challenge?
"It has most certainly been the interdisciplinary work between the cryptology and the HCI group. There are many traditions with regards to building prototypes in computer science, but there is a great difference between why these prototypes are built, what our goals are and what to focus on. To reconcile a prototype, which is tested in its use, and create a proof of concept prototype, which is typically done using security systems, has been an exciting process.

Read more about Niels' work on security and user-friendly design on page 80

Niels is part of the research group 'Human-computer Interaction'. You can read more about this group on page 82



KILO.ONE – HELPING THE FARMER

TEXT: MARIANNE DAMMAND / PHOTO: JESPER VOLDGAARD

KRISTIAN ELLEBÆK KJÆR is a PhD student at the research group "Object-Oriented Software Systems". In Collaboration with the Danish Agricultural Advisory Service (DAAS) Kristian is developing software that supports the registrations of the modern farmer.

How will your prototype help the farmer?
"In large pig farms with a large number of stalls the farmer carry out daily tasks that he is obliged to register: medication, treatment, counting of sucklings and fatalities, etc. They will typically walk around the stall making notes in a notebook, which will then be entered into a computer. In our project the farmer enters the information into a PDA. The PDA is able locate the farmer and the user interface for the specific stall will appear.

How will you describe the development of your prototype?
"It has been an exciting and different process in the way that I needed to acquaint myself with the way farmers work, in order to be able to create a prototype that can simplify their daily tasks. One of the biggest challenges has been coordinating with the farmers who can be difficult to get hold of, especially during the summer.

Read more about the research group 'Object-oriented Software Systems' on page 70.

THE DIGITAL TOOLBOX

TEXT: MARIANNE DAMMAND / PHOTO: JESPER VOLDGAARD

CLEMENS NYLANDSTED KLOKMOSE is a PhD student and affiliated to the HCI research group. He is experimenting with a digital toolbox applicable between different user interfaces.

What does your toolbox contain?
"My prototype is an outline of a software architecture that provides support for several interactive technologies to be in play at the same time. The toolbox contains tools that can be moved from one technology to another and used where most appropriate. For example, you can move your crop tool from your PC to your PDA.

How do you see your prototype in the future?
"A product ready for the market is still a long way off, but I envisage that companies such as Nokia or Apple, which develop technologies of various sizes, would benefit from integrating such an interaction environment into their products, for example, it could quite easily be implemented in the iPhone".

Read more about the work on the digital toolbox on page 84

LIWAS –THE INTELLIGENT ROAD SENSOR

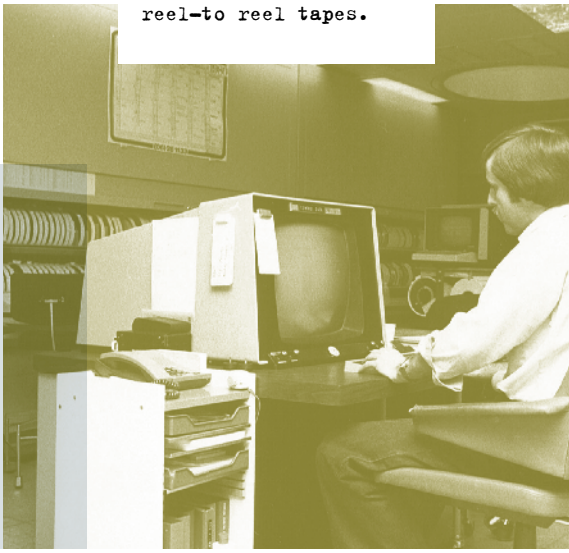
JEPPE BRØNDSTED is employed as a postdoc and is affiliated to the research group Object-Oriented Software Systems. In the research project LIWAS, Jeppe has worked on an icy road sensor that can be fitted into cars.

What is special about the prototype?
"The system can measure whether the road is icy and relay this information to motorists in the vicinity and to other interested parties. Our part in the project is about software architecture and communication and we have mostly been involved in developing the software that processes the input from the sensor and ensures that the information is relayed."

What benefits have been gained from the work on the prototype?
"With prototypes you are bound by real circumstances. It is fun when you have something tangible to work with and where you can easily see the relevance in what you are working on. Prototypes can contribute to driving the research forward and now as the project is complete I will continue to work with the basic ideas behind the project and use them in other contexts."

You can read more about the research group 'Object-Oriented Software Systems' on page 70

TEXT: ANN EG MØLHAVE / PHOTO: JESPER VOLDGAARD



Jens Rønholt working on the successor to CDC 6400 – CDC Cyber. In the background there is row upon row of reel-to reel tapes.

Once upon a time there was a department...

A lot has happened to the Department of Computer Science since the early 1970s. We will now tell the story of a department that has developed in parallel with technology.

BY ARNE VOLLERTSEN
PHOTO: JØRN THERKILDSEN

There was a time when there was only one place in Århus where you could get to use a computer. This was on the "computer floor" of what at this time was called the Computer Science Department, Department of Mathematics, Aarhus University.

At this time the computer scientists were working on the development of computers. This work ceased a long time ago. However, computers are once again being developed, but on a completely different level.

Soldering irons and artificial intelligence

If we go back to the early 1970s the computer scientists in Århus focused on three subjects:

- "To construct computers using soldering irons and everything this entailed.
- "To understand the potential of the computer. What was it capable of? This involved Complexity Theory and formal languages: What kind of theoretical possibilities and limitations did the computer have?
- "To speculate about artificial intelligence: are computers able to become as intelligent as humans?

The picture is now somewhat different. Today the construction of computers is a highly industrialised process. Should a researcher wish to pursue this path, he or she should find employment within the industry. The design of hardware at the Department of Computer Science ceased a long time ago.

On the other hand, the work on Complexity Theory continues. There are still issues that need to be resolved. They are continually becoming more subtle, but they are still there.

The answer to artificial intelligence has been found. "No, we cannot give computers human intelligence, however, the concept of intelligence has been dismantled since

Operator on RECAU, Jens Rønholt. The panel is from a CDC 6400, in its 1981 guise.

Jens Ebbe Thomsen playing with paper tapes from a paper tape reader, RC 2000. The paper tape reader was part of the setup for GIER (Danish Geodetic Institute's Electronic Calculating Machine).

the 1970s. Some people believe that we have seven intelligences and that computers may have an even greater number of intelligences. In brief: in some areas the computer is more intelligent that a human, in others less.

"No, we cannot give computers human intelligence"

Using a computer

After the initial wave of fascination of the early 1970s about what a computer was and what it was capable of, at the end of the decade people started to focus on the question of its possible applications. This emerged a number of new research areas.

These included looking at efficient algorithms and how these algorithms are expressed in programming languages. The languages, that is how programmers and computers communicate, became a new central research area.

Furthermore, research within modelling and validating systems as well as research within participatory design and human interaction, i.e. how systems are developed in the context of people and organisations initiated.

Special disciplines

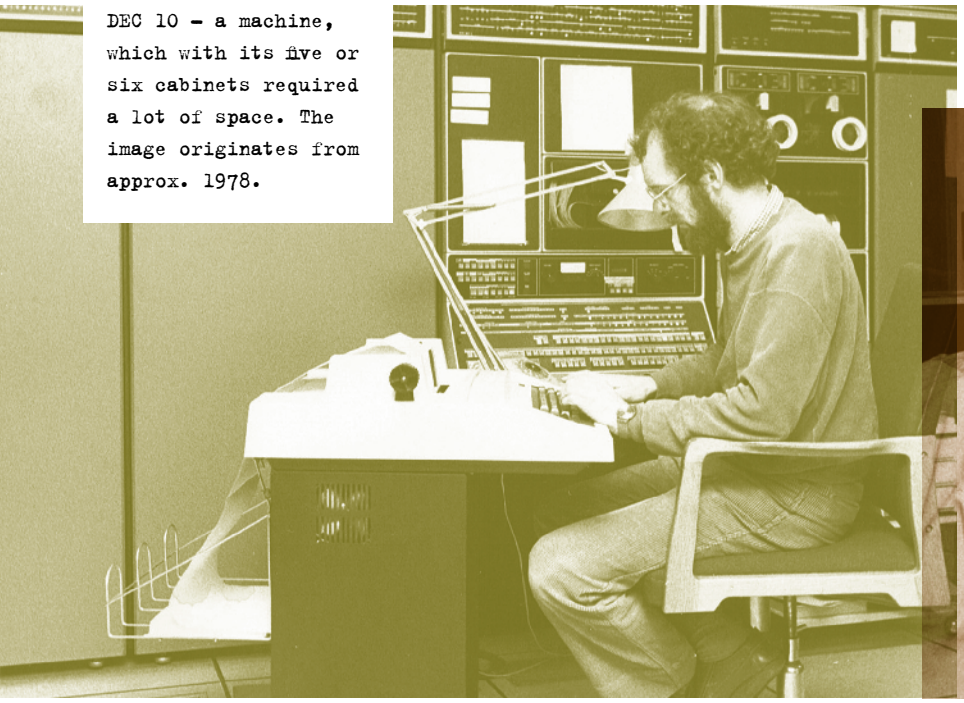
During the last 10-15 years these areas have further developed and have fragmented into a number of special disciplines. At the same time interdisciplinary collaboration is increasing in such a way that researchers from many different areas of the department often work on the same project. Algorithmics have developed significantly over the last few years, primarily via the department's new Center for Massive Data Algorithmics, Madalgo. The work on programming languages is continually developing and complexity theory is still relevant and does now also focus on game theory. In addition to this, user interaction and system development in context have grown into a large and richly-facetted area.

And on top of all a new concept has emerged: pervasive computing or "IT in everything". And so we have returned to computer construction. Computers are now again being constructed at full

Period of study

The average period of study for a computer scientist is particularly low. Computer science candidates are 26 years old, in both the average and the median. The corresponding figure for PhD students is 28.5 years. As we start school at the age of 7, it is almost impossible to do this any faster, therefore not much time is wasted in travelling to Nepal or in failing. The period of study has for many years remained unchanged at around 6 years. On the other hand, the average period for writing a thesis has fallen. This is primarily due to the introduction of thesis contracts that set a clear framework for the writing of a thesis.

A researcher sitting, engrossed in the operating desk for Daimis DEC 10 – a machine, which with its five or six cabinets required a lot of space. The image originates from approx. 1978.



One of the department's first students; Ewald Skov Jensen, sitting by the department's IBM 1130s. The machine was used for data transmission in relation to the CDC 6400. It was, however, also used for entertaining things, such as printing out Snoopy dogs.

76,8 %

Århus holds onto its computer scientists. The vast majority of them remain in Århus and its environs after completing their education.76.8 percent of the members of Datalogforeningen (Association of Computer Scientists) reside within the postal code areas 8000 to 8999.

throttle at the Department of Computer Science. Now it is only about "Gizmology": being able to incorporate a chip with communication capabilities into virtually everything". The computer is, so to speak, everywhere. No longer does it stand like a fridge, humming in a corner, but is instead embedded into our surroundings. This allows researchers to combine gizmos and technologies in new ways. The soldering iron has returned, so to speak.

The students

And what about the students then? Their relationship to the computer has changed radically.

During the first years they were attracted to computer science, partly because computer scientists had something that nobody else had. To begin with, computer scientists were the only people who had computers. Then computer scientists were the only people who had computers with graphical user interfaces. And for a period of time computer scientists were the only people who had the Internet.

However, all of this has reached a saturation point. Today the students' private computers are at least as impressive as those of the department. They are no longer attracted by the equipment, on the contrary they are attracted by the knowledge that they can achieve.

Already before commencing their studies the new students have had a great deal to do with computers. However, at some point they will meet their own limitations and will need to know what is actually going on inside the computer. And this is where computer science comes into the picture.

"For a periode of time computer scientists were the only people who had access to the internet"

Changed study environment

The students have therefore changed and needless to say, so have the study environment. In those days when computer scientists had the only computer in town, groups amassed on the computer floor and studying computer science was therefore almost a way of life.

In the summer of 1972 the computers were moved from one building to another. Little more than a roller table was needed to move the computers of the time.

In the 1970s it was normal to stand in a queue in order to get time on the computers. Today there are more computers than students at the Department of Computer Science.

Today a large number of students attend lectures and then work on their own computers at home. The study environment at the Department of Computer Science has become more fragmented. A development that is good for some and perhaps not quite so good for others, a situation that requires constant pedagogical innovation

At the same time, the department has become a more dynamic place. Its links out into the community, the business world and other educational and research institutions are stronger and more diverse than ever. There is an abundance of collaboration across all departments and disciplines, both internally within the university and externally in the business community, public authorities, the town and its citizens. There is IT in everything and there is computer science in diverse and diffuse areas, whether these are research projects with Bang & Olufsen, internships for the new IT-bachelor degree or play and learning using LEGO robots for primary and lower secondary school pupils.

In brief about the Department of Computer Science: There has never been as much progress in the department as now.

The World's most acknowledged IT researcher

Olivier Danvy, associated professor at the Department of Computer Science, is the computer researcher who has received the greatest number of acknowledgements from other researchers. This is evidenced by a review of 335,000 research articles conducted by researchers at Pennsylvania State University in the USA. They have developed a data-mining-program that examines scientific publications and can find out who is acknowledging who in the "acknowledgements" section of these scientific articles. Olivier Danvy conducts research into programming languages and according to him the large number of honours are due to his major involvement in an international PhD programme and his work within a number of different areas.

Source: Michael Schwartzbach, Chairman of Educational Comitee.

Candidate no. 1000

In January 2003 computer scientist no. 1000 graduated. His name is Frank Allan Hansen and he now works as a postdoc in the department's Center for Interactive Spaces. Frank is working on the UrbanWeb project, which develops mobile services for the urban environment, based partly on "semacodes", a special type of barcode that is read via a mobile phone. Read more about UrbanWeb at www.interactivespaces.net.

ON TOP – AND IMPROVING

THE HEAD OF THE DEPARTMENT, KURT JENSEN, ON FUTURE RESEARCH TOPICS AND THE GROWTH STRATEGY FOR THE YEARS AHEAD

BY ARNE VOLLERTSEN

It is gradually becoming a cliché, but nevertheless still true: IT is everywhere and everybody and everything depends on IT in one way or another. This frightens some people, while others can only see the opportunities.

Kurt Jensen belongs to the latter. From his central location in the country's strongest computer science research environment he predict a multitude of opportunities for growth in the future: new research areas, more research grants, more PhD students, an even higher quality of research and even more collaboration with commerce and industry.

The department has already attained a high level in all of these parameters, but Kurt Jensen believes that it can still improve.

Interdisciplinary perspectives

"There are some exciting perspectives for research at the Department of Computer Science. This applies internally within the Department, where the existing research groups work together across their various disciplines. And it also applies externally, where computer science has many interfaces out to other disciplines."

"A subject such as e.g. scientific computing: researchers within, for example, biology, physics and chemistry amass continually increasing quantities of data. To be able to acquire new knowledge from these data super efficient algorithms need to be developed, which can perform complex calculations on the enormous quantities of data."

"Computer Science is continually becoming more important to other sciences and interdisciplinary fields are being created, such as bioinformatics, for example, which combines biology with computer science knowledge of algorithms and data structures. Or quantum cryptography, which lies in the border area between cryptography and physics."

THE DEPARTMENT OF COMPUTER SCIENCE HAS:

the highest number of PhD students in relation to the total permanent scientific staff, both compared with the other departments within the Faculty of Science, Aarhus University and compared with other computer science environments in Denmark.

Pervasive computing

"Another important research topic is pervasive computing – IT in everything. The success of pervasive computing systems is largely dependant on their user interfaces, software architecture, efficiency and the networks and protocols that provide computers with dynamic access to resources on other computers. At the same time, the reliability of these types of systems is of vital importance.Therefore, it is important to be able to validate and verify a system before it is put into use."

"A promising borderland between cryptology, security, and human-computer interaction has also arisen. If users are unable to understand the relevant security aspects of a system, they will make poor decisions, whereupon security is lost. The actual security of a system is therefore dependant not only on its technical design, but also on its usability. We already have a number of promising projects in this area and more will follow."

Interdisciplinary collaboration

Interdisciplinarity is becoming increasingly important, both internally within the Department of Computer Science, in collaborations across the departments of the Faculty of Science and in collaborations with other institutions.

Aarhus University has already assembled the majority of its IT programmes and IT research at Katrinebjerg. Moreover they are collaborating with Aarhus School of Architecture and Aarhus School of Business, the latter of which is now part of Aarhus University. Furthermore, the Engineering College of Aarhus has decided to locate its unit for IT and Electronics at Katrinebjerg. The result of this will be an even closer collaboration between the Engineering College and Aarhus University with re-

Over the course of two years the Department doubled its enrolment figures. This means that in 2008 the Department of Computer Science is the largest department within the Faculty of Science, measured in the number of new students. The computer science students constitute almost 25 percent of all new students within the Faculty.

PHOTO: JESPER VOLDGAARD

gards to the existing Master of Engineering education within Technical IT.

AU's strategy

It is completely in line with the university's overall research strategy that the Department of Computer Science focuses on increasing its future research production, in both quantity and in quality.

This applies, for example, to the number of PhD students.Everywhere within the university focus is being laced on radically increasing the number of PhD students. This is also taking place at the Department of Computer Science, which already has 70 PhD students. This is a high number, both compared with other departments within the Faculty of Science and compared with other Danish IT departments. The development is accelerating at such a rate that in 2012-2013 more than 100 will be taking a computer science PhD degree at Arhus University.

All together, an increase in the volume and quality of the research is an important element of the department's future plans", says Kurt Jensen.

Absolutely at the forefront

"Comparing ourselves with the other

Danish IT departments, we are absolutely at the forefront with respect to research", states Kurt Jensen.

"This can be seen from the external research grants, which we obtain every year in free competition with other researchers.The total amount is approaching DDK 50 million a year and the trend is increasing. If you look at the quality of the research, the department is also at the forefront. On the basis of the so-called H-index, which assesses the quality of research on the basis of the number of researchers who refer to their publications, the Department of Computer Science at Aarhus University is ranked far higher than other IT departments in Denmark."

> "When we compare ourselves with the other Danish IT departments, we are absolutely at the forefront with respect to research"

More students

The department has also seen a massive growth in terms of student intake", says Kurt Jensen.

"In both 2007 and 2008 we have seen a large increase in the intake of new students. Over the course of two years the department has in actual fact doubled its enrolment figures. This means that in 2008 the Department of Computer Science is the largest department within the Faculty of Science, measured in the number of new students. The computer science students constitute almost 25 percent of all new students within the Faculty."

A broader segment

"One of the reasons for the large number of applications is that we focus on a broader segment of students. Besides students with a technical approach to computer science we also look for people who are interested in for example design and the use of new types of devices, user interfaces as well as commercial aspects."

"This change is most noticeable in our new IT bachelor programme. It has always been possible to follow a computer science programme with a broader aim and less focus on mathematics. However, with the IT bachelor programme, we emphasise design and business-orientation and slightly moderate the focus on computer science courses that are heavy in mathematics."

"Generally, we would like to have students who besides a technical interest are also interested in how IT can be used. A good computer scientist has many skills and competencies besides programming abilities at a high level. And by focusing more on this broad spectrum of skills and competencies we hope to be able to attract even more students, not least more female students. IT has an enormous influence everywhere and its development must not be solely entrusted to engineers. Therefore, interdisplinarity and diversity are of high priority at the Department of Computer Science."

PHOTO: MORTEN FAUERBY

PHOTO: MORTEN FAUERBY

PHOTO: METRO AG

PHOTO: METRO AG

PHOTO: PARCOM

PHOTO: PALCOM

Pervasive computing is all about IT in everything. With interdisciplinarity and user-driven innovation as supporting principles, the Department of Computer Science is a leader in this field.

IT everywhere

BY STIG ANDERSEN

It is early in the morning, it is dark and the first employees are arriving at the newly-constructed company domicile. When entering their offices, the lights are automatically turned on. A little later the sun appears and the venetian blinds automatically descend. Activated by a given situation (the presence of the personnel inside the offices and the sunlight from the window) an automatic adjustment of the surroundings takes place on the basis of an assumption of what is correct for these very people at this very place and at this very time.

This is practical in many situations. But what if the personnel would actually prefer to work with just their own desk lamps turned on, or perhaps spend a couple of peaceful minutes watching the beautiful rising sun? Then a program on the PC needs to be opened in order to adjust the standard settings for the automated office need to be adjusted. "If your office colleagues agree with this that is".

On the way home from work our friend from before listens to his latest MP3 purchase. The noise in the carriage varies according to the acceleration and rotation speed of the engine, but the volume of the car stereo is automatically adjusted so that he is able to hear everything. Suddenly the vehicle ahead slow down, our friend slams on the brakes and the ABS brakes do their job, completely automatically. Having arrived home safely he sits down in the lounge, where the temperature is just right. This is automatically ensured by the thermostat.

People in focus

The above are everyday examples that illustrate a fundamental challenge in Pervasive Computing, also known as "ubiquitous computing". Most people are probably very glad that a chip in the vehicle ensures that the brakes do not lock


PHOTO: PALCOM

and that they do not have to constantly turn the radiator up and down. However, most people would certainly like to have access to a physical button if they wanted to get the automatic venetian blinds to rise again in order to enjoy the sunrise.

So how concealed and automated should technology be and is it at all possible to capture a person's intentions and needs in underlying system logic?

The vision of Ubiquitous computing was formulated in the late 1980s by Mark Weiser, who at that time worked in the Computer Science Lab of Xerox PARC.

Weiser advocated that IT would gradually become embedded and therefore ubiquitous in our physical surroundings. IT should evolve from being something we use by means of screens, mice and keyboards to being embedded in our surroundings to such an extent that, in use, it would be invisible. Instead of paper, pencils and blackboards there would be tabs, pads and boards in the conference room, he argued. And users would have access to relevant data and communication options, based on who and where they were. The ultimate goal was to evolve from a computer-centric approach to a human centric approach. Therefore the presence of IT in everything should also involve a fundamental shift in our perception of a user's interaction with technology. From discussing graphic user interfaces and the number of buttons on the mouse, we now had to relate to other types of interaction and concepts, such as transparency: How visible should technology be (in both the literal and operational sense) and what demands did it place on the design of the interaction so that we would not only encounter IT in the form of a desktop computer.

Århus in front

For several years the Department of Computer Science has worked intensively with pervasive computing. As the core areas of the department had to be defined at the turn of the Millennium, activities within mobility, embedded software and hardware, communication and new types of interaction were increasing rapidly. The researchers at the department believed that these areas held some very promising future perspectives for experimental computer science, and pervasive computing was chosen as the best headline to cover future activities in this field.

Shortly afterwards a large conference was held, where the IT industry identified pervasive computing as the most important new "mega trend" from a commercial perspective. A few years later, in a report from IBM, Århus was identified as the best location for companies that wanted to develop products within the field of pervasive computing.

Because of the department's focus on pervasive computing, in 2004 it was assigned to direct the major EU project PalCom, which developed software architecture for pervasive computing that could make the technology understandable and tangible for users.

Interdisciplinarity and user participation

In experimental computer science and therefore also within the department's work on pervasive computing the development of tangible systems and prototypes plays a major role. Everything is based on a strong tradition of interdisciplinarity and user participation during the development phase. The position is that if we are to discover relevant solutions, including an interaction design, which eliminates the technical element as a barrier to the user, future users must be involved at a much earlier stage of the development process. To top it all off, quantitative research has demonstrated a greater economic potential in projects than in ideas produced in the more isolated setting of a research environment. The tradition of user participation (also known as "user-driven innovation") has its origins far back in time. The major Utopia project of the mid-1980s was an important milestone. The original focus of the project was IT for the graphical industry, but during the course of the project it transpired that what was even more important were new methods to support cooperation between engineers and future users.

The project became internationally known for these methods and the underlying vision.

"Quantitative research has demonstrated a greater economic potential in projects than in ideas produced in the more isolated setting of a research environment"

PHOTO: METRO AG

PHOTO: MORTEN FAUERBY

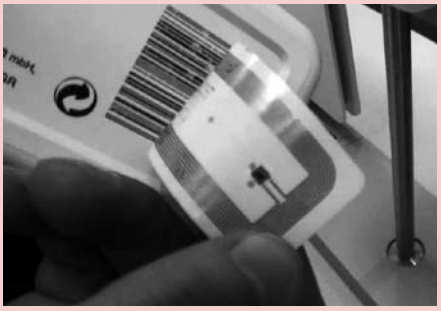


PHOTO: METRO AG

Interdisciplinarity gains acceptance both internally between the various research groups of the department and externally, where people from other disciplines such as architecture, ethnography and the aesthetic disciplines are involved.

There are other research environments that have also gradually gone this way, but the Department of Computer Science at Århus did so at a very early stage and today continually differentiates itself by consistently basing its experimental projects on an interplay between interdisciplinarity and user participation.

Visible and invisible technologies

The activities conducted by the department in the field of pervasive computing are driven by a fundamental idea that in our surroundings IT should be something that works. Something that gives meaning to users and something that they have faith in because they are aware of what the systems do for them. Thus we do not believe in the extreme version of transparency, where technology must as a necessity disappear quite literally. Firstly, there will always be a phase in which users could acquire this new technology; secondly, access must be provided in order to carry out error corrections and improve the underlying technology. Both of the above require visibility. The great challenge lies in the necessary interaction between IT as an embedded part of our surroundings and the consequent necessity to periodically make it visible – and today a lot of research work still remains.

It is not a belief that a system logic can be developed that would allow us to speak about a kind of intelligence. We can develop systems that are able to react to specific situations in the surroundings. However, with the technology that is currently available, a technologically-supported contextual concept will always be poor in comparison with the conceptual concept on the basis of which a human either consciously or unconsciously acts. We therefore focus on finding the correct balance between automating the trivial procedures, where being informed of what the system has done would only serve to annoy the user, and to allow the user to make relevant decisions at the right time and place. It is a fundamental concept that the systems must support users in their response to exemptions and faults since these often determine whether the systems actually pass the test in practise.

Another approach to pervasive computing that is also cultivated at the department is the idea that interaction with technology can be an experience in itself and contribute to promote the social and playful sides of people.

We talk about aesthetic interaction, where we endeavour to activate all of the senses and the whole body in the very interaction with technology.

The concept will disappear

Pervasive computing is a broad concept, which at the Department of Computer Science is primarily cultivated within the areas of pervasive healthcare, pervasive positioning, IT security in connection with pervasive computing, interaction design in connection with pervasive computing and the requisite underlying software architecture. Over the years the department has been involved in innumerable projects and prototypes, which originated from the work, conducted within these areas. Some of these were product developed and continued in a commercial direction. Today pervasive computing is a hot topic with regards to research. However, the department expects that within ten to twenty years pervasive computing will no longer be an independent concept, since at this time IT will be just as natural a part of our surroundings as power and water. However, even if this does happen, there will still be a multitude of challenges in conducting research into the interaction between humans and technology and the development of the most suitable platforms for this interaction.

"The systems must support users in their response to exceptions and faults since these often determine whether the systems actually pass the test in practise"

Algorithms designed to handle massive amounts of data are comparable to baking recipes, believes Professor Lars Arge. Many of today's algorithms are equivalent to flying to Australia for eggs, to the USA for flour and to China for sugar when baking a cake.

PHOTO: AU FOTO

MADALGO CONTROLS THE

data tsunami

A computer can be made to work several thousand times faster by planning the needed calculations effectively. The basic research centre MADALGO works on finding the most intelligent algorithms to do so.

BY PETER F. GAMMELBY

The World is being flooded by such massive amounts of data that even the newest and most powerful computers cannot keep up. In 2007 the analysis company International Data Corporation estimated that 988 exabytes (or 988 billion gigabytes) would be produced and copied in 2010.

Not only do we all save data on our computers and upload it to the World Wide Web; sensors, cameras, telephones and all sorts of electronic equipment that surrounds us contribute to creating this tidal wave of information.

"The opportunities offered by the massive amounts of data are equivalent to nano technology, in the sense that we are still unable to exploit the tremendous opportunities they offer. There are so much data and so many possible applications", says Lars Arge.

MADALGO

Lars Arge is the director of center for massive data algorithmics (MADALGO) under the Danish National Research Foundation, in which Danish researchers since 2007 have worked with colleagues from the Massachusetts Institute of Technology (MIT) in the USA, and the Max Planck Institute for Informatics (MPII) and the Goethe University in Germany on the development of efficient algorithms for handling massive datasets.

The level of activity within MADALGO has been high from the outset, and its growth almost explosive. The centre currently consists of six core researchers from the four sites in Denmark, the USA and Germany, as well as six Post Docs and fifteen PhD students. In addition, towards fifty guest researchers from many different countries have visited the centre. MADALGO has also won the task of arranging one of the top conferences within the field in 2009, namely the "Symposium on Computational Geometry (SoCG, pronounced "sausage").

And as hoped, the centre has been successful in starting interdisciplinary collaboration. For example, one of the PhD students (who is a biologist) is creating advanced biodiversity models.

Power limits

One of the reasons for the increased interest in algorithms for processing massive datasets is the fact that the data-tsunami cannot be handled by increasing computational power.

The exponential growth in computational power over the last 40 years cannot continue.Transistors cannot continue to become smaller and heat exchange from processors is becoming a problem.

Furthermore, the amounts of data are growing at an even faster rate than that of computational power.

Finally, massive amounts of data are a relative concept: even a small dataset can seem large for a small computer.

On the other hand, using efficient algorithms even very large datasets can be made manageable for normal computers.

Effective sorting

"It is all about exploiting that a computer not only retrieves the specific data that is asked for from a hard disk, but a block of data of 8, 16, 32 or 64 Kbytes at a time. Thus, data that is not used will often be retrieved, while time will have to be spent on retrieving other data that is actually used.

"The tidal wave also contains an ocean of goldmines, both for researchers and for business people. All that is required is to find the tools needed to mine the massive datasets"

On the other hand, if the data is sorted on the hard disk in an intelligent way, all the data in the retrieved blocks will be used, thereby saving a lot of time. And we are very good at sorting the data in this way", says Lars Arge.

He proved this a few years ago when his then research group at Duke University in North Carolina, USA, was simulating water flow on a terrain model covering a 64 million hectares area in the American Appalache Mountains.

"It was all about processing the data in the right order. You divide the model into cells and sort them by height, while augmenting each cell with information from the neighbouring cells. By doing so the size of the data will actually increase by a factor of nine, but on the other hand you can ensure that much of the data that is retrieved in each block can be used. This reduced the computer time for a simulation from two weeks to three hours – on the same machine", explains Lars Arge.

"It reduced the computer time for a simulation from two weeks to three hours - on the same machine"

Streaming data

However, I/O-efficient algorithms cannot be used on all massive datasets. Some datasets are actually never stored, or are not stored long enough to be retrievable more than ones. Sometimes the data can also be so enormous that one can only afford to read it one single time.

Therefore another of MADALGO's focus areas is streaming algorithms, which are algorithms that are based on reading the data ones in the order it comes from a sensor or in the order it is located on a hard disk.

"Streaming algorithms are for example used in network monitoring applications, where data is only important at the present moment. In such cases it is all about using as little time and space as possible for each piece of data. The network could for example be a telephone network, and the applications used to detect whether faults occur, or where extra capacity should be deployed", says Lars Arge.

Instead of counting the number of occurrences of each data value in a large data sequence using a lot of space, one can use a streaming algorithm that use very little space but calculates the most frequently occurring data values with high probability.

Cache oblivious

A third focus research area of MADALGO is algorithms that are "cache oblivious", that is, they are indifferent to what type of memory the data is retrieved from.

The idea is to minimize reading and writing on all memory levels, both the L1 and L2 caches, the RAM and the hard disk.

The goal is to achieve algorithms that are efficient on all platforms - from super computers to mobile phones.

"This is the least developed and most theoretical area of the four center focus areas. However, a number of breakthroughs have recently been made. For example, it has been shown how to optimally sort data at all memory levels of any computer - at least in theory", says Lars Arge.

Relevant and practical usage

The fourth and final focus area of MADALGO is "algorithm engineering". This is research into how the theoretical results can be applied in practise.

"We are attempting to implement practically efficient algorithms, and are experimenting with them for example to further develop the theories. The distance between basic research and practical applications is not very large in algorithms for massive data, since the motivation is very practically relevant: The dataset sizes are increase exponentially", states the professor.

www.madalgo.au.dk

The big game

In an increasingly more complex world game theory can create clarity. All types of multi-agent systems such as traffic analyses, online auctions or global commerce can be described and analysed mathematically using game theory.

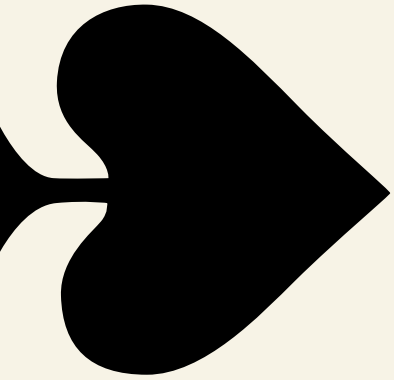
BY ARNE VOLLERTSEN

"A good many situations can be considered as "games" and can therefore be analysed in the same way. This gives us a wealth of opportunities for interdisciplinary projects", says Peter Bro Miltersen. He is head of the Center for Algorithmic Game Theory, which is financed by the Carlsberg Foundation and he is busy trying to obtain additional funds for his research area, which includes collaborating with the department's cryptography group and the School of Economics and Management at Aarhus University.

"Those who work in the centre are basic research orientated, which means that we primarily look at the more fundamental aspects of game theory, including solution concepts and auction theory. However, these are also at play in tangible situations, in fact many millions of times every day.

"With game theory you can analyse situations where each player (or agent) has some specific interests. The search engines Google and Yahoo employ game theorists, among other things to analyse advertising. They understand how to

RESEARCH INTO
ROYAL STRAIGHT FLUSH



After 2,200,000 hands of poker Troels Bjerre Sørensen could call himself the unofficial world champion of robot poker.

TEXT AND PHOTO: BJARKE ROSENBECK

Troels Bjerre Sørensen has a PhD degree in computer science and is employed as a postdoc at the Center for Algorithmic Game Theory, which is financed by the Carlsberg Foundation.

During the working week he is not the biggest poker shark, but he has nevertheless become the unofficial world champion of robot poker. However, this is no usual poker tournament.

The tournament was held in conjunction with the AAAI 2008 Conference (Association for the Advancement of Artificial Intelligence) in Chicago, USA. In this championship the participants do not sit around a table with piles of colourful chips and big bundles of money, they instead send in poker bots, which are programs that can play poker.

2,200,000 hands of poker

Together with two researchers from his stay at the Carnegie Mellon University, Troels Bjerre Sørensen was the winner of the category "Heads-Up Texas Hold'em Limit" – a category in which each player can only stake a fixed amount every time. Troels and his group also took part in the second category of the competition, "Heads-Up Texas Hold'em No Limit". In the No Limit competition Troels Bjerre Sørensen actually had the program that won the most chips on average. However, the group did not win this category as their high average was due to the fact that they won a large number of chips from the weakest opponent.

During the competition the participating poker bots play against each other again and again. During the course of a month, 16 computers played some 2,2 million hands of poker.

Exploit the weak

In order to become the winner of the unofficial poker world championship, the participant must be able to develop the program using the best algorithms.

The fact that the program Troels Bjerre Sørensen and his group developed could stand out as the best, can be largely attributed to the ability of the program to exploit the weakest opponents, he says,

"There are two ways of developing poker bot programs. You can either program all of the poker tricks you know into

define the rules of the game so that the returns are as high as possible, at the same time as giving the searcher the service that is required.

A game of Ad Words

Peter Bro Miltersen says that even Google uses game theory:

"In game theoretic terminology the "Google Ad-words" system is called a "Generalised Second Price Auction". What is special about this is that the advertisers do not pay for what they offer themselves, but for what the following advertiser offers. In this way we achieve, what we in game theory call a "Nash Equilibrium in Pure Strategies". You achieve a stable situation, which means that nobody can advantageously change their offer. A situation that is not achievable by demanding the advertiser to pay what he actually offers.

"Google's "Generalised Second Price Auction" is the most frequently performed auction. It runs millions of times every day and today many game theorists publish papers on this type of auction. One of the trends that can be seen in research these days includes the development of more specific models of the searcher and his behaviour.

Auctions are flourishing on the Internet

Researchers at The Center for Algorithmic Game Theory are working in various directions. They collaborate with cryptographists on game theoretic analysis of cryptographic protocols. And more oriented towards basic research, complexity theory is used as a tool to evaluate the quality of a solution.

"We collaborate with economists on auction theory in particular. On the basis of game theory principles we can attempt to optimise auctions such as Google's Ad words. This is an area that is blossoming because the Internet makes these types of auctions possible. And the complexity involved in these situations necessitates the use of algorithmic methods for analysing them.

Read more about the work of Peter Bro Miltersen on page 74

the game and make the program play according to these. In this way you will have a program that plays as well as you do yourself. We did not use this method because we are not actually particularly good at playing poker. We therefore developed a program that creates rules for how situations are to be grouped according to concurrence. The grouped hands are then forwarded to an optimising algorithm.

Decisions reached on a flimsy basis

The fact that Troels Bjerre Sørensen has succeeded in developing a winning program must first and foremost be attributed to a technical competence and interest in game theory that far exceed his abilities at the gaming table.

For Troels Bjerre Sørensen research into game theory is all about being able to predict what will happen. A challenge that is not made any easier by the fact that the poker robot does not know what card its opponent is holding.

"Game theory is about making decisions on the basis of a mathematic analysis", Troels Bjerre Sørensen explains.

Game theory can help us decide how we could advantageously act in the situation on the basis of incomplete information.

However, Troels Bjerre Sørensen should not count on a well-paid job as the developer of poker programs for the numerous websites that offer users the chance of playing poker online. For even if poker bots can play on equal terms with humans, it would be fatal for business if a site were to be caught permitting the use of poker bots. On the other hand, there are numerous examples of recognition of the best game theory researchers. Recently there have been game theorists among Nobel Prize winners on three occasions within the last few years.

In collaboration with other commercial groups the SensoByg consortium is working on a solution that involves the use of wireless sensors embedded into concrete elements.

Sensor technology

IN INTERDISCIPLINARY COLLABORATION

BY BJARKE ROSENBECK

SensoByg is an innovation consortium that is working on the development of a wireless technology allowing small wireless sensors to be embedded in concrete structures. The sensors will then be able to measure the moisture in the concrete. This is very advantageous. When used in new concrete construction projects the sensors will be able to help providing information on when the concrete is dry and ready for the next phase. In addition, the plan for the embedded sensor technology in the concrete elements is that the sensors will be able to provide important information regarding the condition of the concrete throughout its service lifetime.

The vision is that the sensor technology may be used in all phases of concrete construction. This places several demands on the technology, which is still in the development phase. The consortium is supported by DKK 11 million of public money, which over a period of three years will be used to create the basis for a series of specific projects.

From concrete to user

In the Department of Computer Science PhD student Morten Tranberg Hansen is working on the part of the project that concerns obtaining the information from the sensors and conveying it to the user.

"Our job is to ensure that the data gathered by our sensor hardware can be distributed on the basis of the network that has been set up. We will then establish a location where we can store data and make it available to users within the systems that they use".

"There is an enormous difference in having a sensor that is to deliver information within the two months it takes the concrete to dry and having a sensor that remains in the concrete and delivers information over the entirety of the concrete's service life"

In addition to the software solutions that Morten Tranberg Hansen is working on, the consortium consists of four other sub-groups. One group is working on the encapsulation of the sensors in the concrete. Another group has the task of drawing up guidelines for when information should be extracted from the sensors.

"There is an enormous difference between having a sensor that is to deliver information within the two months it takes the concrete to dry and having a sensor that remains in the concrete and delivers information over the entire lifetime of the concrete. This is where computer scientists like ourselves make our contribution", explains Morten Tranberg Hansen.

From scratch

In addition to this, a general architecture will be developed. The requirements stipulated for the data gathering systems are so specific that the system is basically expected to be built from scratch.

The last of the four groups of the SensoByg consortium is working on producing the sensors that will be used.

"The sensors must be as small as pos-

sible. This makes them easier to place in the concrete. We are working on the basis of a conception of several types of sensors. An active sensor with a built-in battery, or a passive sensor, that receives its power from other sources", says Morten Tranberg Hansen.

Sensors for all kinds of weather

Up until now the consortium has only had a few test deploys, where attempts were made to embed sensors in a bridge in conjunction with some maintenance work. The experiment would give an idea as to whether it was possible to obtain any information from the sensors in the concrete.

In our experiment, we placed five wireless sensors in the bridge and set up a receiver box on the bridge. The idea was that every hour the sensors would transmit a signal to the receiver box. The experiments have demonstrated that there is great variation in the signal quality.

Weather conditions, traffic on the bridge at the moment of transmission or the distance from the sensor to the receiver box all play a part in the resultant signal that the sensors attempt to transmit to the receiver box.

The contribution of computer science

"The software solutions are still very "prototype-ish". I have now been involved for a year and we are still in a development phase, where we are developing an architecture", says Morten Tranberg Hansen.

The projects still contains many unanswered questions. But gradually as specific scenarios emerge, Morten Tranberg Hansen and the other computer scientists will address questions concerning how the sensors will communicate with each other and how the information will be extracted from the concrete.

"Since we still do not know precisely what the sensors are capable of, part of this work is a little fictitious. However, one scenario is a series of sensors that transmit to each other inside the concrete".

"Another possible solution that we are working on is based on a transmitter on top of the concrete. Let us imagine that this transmitter receives its power from solar cells. The transmitter could then provide a number of passive sensors, positioned inside the concrete, with power", says Morten Tranberg Hansen.

"Weather conditions, traffic on the bridge at the moment of transmission or the distance from the sensor to the receiver box all play a part in the resultant signal that the sensors attempt to transmit to the receiver box"

Not just all data

When the computer scientists enter into a consortium such as SensoByg, in which the development of software takes place in parallel with the development of the specific requirements of the project, an ability to constantly adapt is required. This means that Morten Tranberg Hansen needs to be as well prepared for the final requests from the other groups of the consortium as possible.

Besides preparing solution that work with both embedded active sensors and passive sensors, the development of an architecture that can resolve the task by processing the data that is provided by the sensors is also a major undertaking.

"When you have data from the sensors a number of questions arise: What type of data do the various sensors return and how do you find out how to distribute this data between them – and what formats are we interested in. We will then be ready to deliver usable information to users in the format that they want to use", explains Morten Tranberg Hansen.

Today besides SensoByg's own test deployments some of the collaborative partners of the project are conducting their own experiments. This requires that the system is able to communicate with a setup that consists of several different solutions.

Morten Tranberg Hansen's future research and development will primarily be making the large number of wireless sensors communicate with each other and with a receiver box. There are great challenges in creating a product that provides stable measurements while being energy efficient.

www.sensobyg.dk

On pages 86-89 you can read more about the research group 'Modelling and Validation of Distributed Systems'.

PHOTO: SENSORBYG.DK

During maintenance work carried out on a motorway bridge the researchers were able to install and test the sensor technology in practice.

A physical space is no longer just something in which we live. It is something with which we can interact. Center for Interactive Spaces is making an impact on the research in Interaction Design and Augmented Reality. Read about the many and different types of projects in the center.

Interactive spaces

– new dimensions in the physical world

BY STIG ANDERSEN
PHOTO: INTERACTIVESPACES.NET

The Wisdom Well at the Møllevang School in Århus, the electronic schoolbag, InfoGalleries in the library, information via interactive tags in the urban space for the Århus Festival, AudioMove theatre together with Theatre Katapult, and interactive floors for the Mariko Mori exhibition at the Århus Museum of Art (Århus Kunstmuseum AroS). This is just a small sample of the projects that the Center for Interactive Spaces has been involved in.

The key areas of research in the centre are Interaction Design and Augmented Reality. These areas focus on ICT opportunities to provide digital layers on top of the physical environment, such that digital material and tools can be used in the given context. For users or participants this means that physical spaces are not just something in which they move; they are something with which they interact.

Demo or die

The head of the research center, Kaj Grønbæk, calls the public installations "spectacular prototypes". And the philosophy of the centre is clear, "Demo or die". This conceals an uncompromising approach to interaction design, Kaj Grønbæk says.

"When you conduct research in interaction design, it is very important to make your ideas tangible. Altogether it is quite difficult to have an article published in a scientific journal if you cannot demonstrate the applicability of what you are doing. It is therefore important to "run the risk" and run the prototypes in public spaces in order to document the results of our research based on real world experiences.

But is there a demand for more interactivity in our physical environment? How many interactive refrigerators and information boards do we feel like using? Kaj Grønbæk says, "It is difficult to say exactly when the need is a pull or a push. However, if society does not know about the opportunities there will be no demand. At Center for Interactive Spaces we want to produce relevant and innovative results. And by the term "innovative" I mean something that is actually put into use and not something that just end up on the shelf as a fancy but unusable technology prototype."

Technology for "body – kinaesthetic learning"

The Wisdom Well at the Møllevang School in Århus is an example of a technology that was ahead of its time. It was developed and put into use at a time when the pedagogic world did not exactly cry out for an interactive floor, but they requested facilities where school children could use their bodies for learning. This learning style has recently received a lot more attention among teachers who demand tools that support learning styles, e.g. for the so-called "tactile-kinaesthetic children".

> Open house in Center for Interactive Spaces laboratory. New interaction techniques for an installation in the Kattegat Centre are being demonstrated.

>> The Danish Crown Prince Frederik and Crown Princess Mary visited Center for Interactive Spaces on 26 July, 2004. They tried out the interactive floors, tables and boards.

The development of the Wisdom Well has already made progress in this area due to its early start in 2003, and now a mass product may be on its way to the market.

Interdisciplinarity is the Holy Grail

A condition for being able to think innovatively in relation to the internal and external spaces in which we move requires, according to Kaj Grønbæk, a high degree of interdisciplinarity. Center for Interactive Spaces is therefore collaborating with architects and other specialist groups with a musical and aesthetic approach to things.

And combined with active user involvement in the projects, this provides a very fertile research environment.

"We don't have much faith in the heroic innovation model, where a bright researcher is expected to develop great ideas alone in his laboratory. We believe more in a combinatorial or organic model, in which an interdisciplinary group of researchers and users are involved, such that a number of relevant competencies come into play", says Kaj Grønbæk.

Unique profile

Center for Interactive Spaces is not alone in its research into interaction design. However, according to Kaj Grønbæk, the centre has its very own profile.

"We are especially known for our user-driven approach and the interdisciplinary mix that can be found here at Katrinebjerg. And we were also relatively early in releasing our thoughts on linking together architecture and industrial design", he says.

Professor Uffe Lentz and Associate Professor Peter Gall Krogh from Department of Industrial Design at Århus School of Architecture have played an important role in bringing physical design into the research conducted at Center for Interactive Spaces. Interdisciplinarity also means that the research and projects of the center receive attention from many different fields. Over the early years of the center there, more than hundred scientific publications have been produced. And several of the concepts that the center has introduced from its research are today used as generic concepts. This is true e.g. for the notion of aesthetic interaction, and for the definitions of different types of hypermedia developed in the center's projects: Context aware, physical and geo-spatial hypermedia.

"It is all about ICT opportunities that enable us to provide digital layers on top of the physical environment, enabling it to be come interactive and provide relevant services"

The center has also won a number of prizes for presentations at conferences. Finally, the centre has held many popular presentations, where the research of the centre has been made available to a wider audience.

Recognition has come from the design world in the form of several prizes, most recently in 2007, when the Wisdom Well was presented with the prestigious Red Dot Best of the Best Award in the Design Concept category.

ICT should be transparent

The research at Center for Interactive Spaces generally belongs to the concept of "Pervasive Computing", which is concerned with ICT embedded into the surrounding objects and environments that constitute the context of our everyday lives. Embedded ICT enables us to interact with the physical framework of our everyday lives in a way that we do not perceive as being an application of ICT.

"One of the fundamental theses in this context is that ICT will end up being just as transparent as the written language, where we are no longer aware that we are using a very complex "code". We just consume the text as communication. In the same way we would like to end up just using the needed tools without being "disturbed" by the fact that they contain ICT. In the future, ICT services will be just as natural as electricity and water are today", Kaj Grønbæk claims.

Today there are huge amounts of physical products that only posses value because of their digital services – GPSs, iPods, are prime examples. And in a modern car much of the functionality is provided by built-in computers that do not need to be operated explicitly by the user. Kaj Grønbæk predicts that this development will continue rapidly.

"Today we almost never think of new products without thinking integrating ICT into them. However, there are still products for which it can be difficult to envisage embedded ICT – furniture, for example. In any case, there are still many challenges that need to be met within the area of interaction design before the interaction with ICT becomes as natural as using electricity or water today", he concludes.

www.interactivespaces.dk

IT in the home

MUST SUPPORT THE SOCIAL LIFE OF THE FAMILY

BY STIG ANDERSEN / PHOTO: INTERACTIVESPACES.NET

IT in the home can promote social and leisure activities amongst family members. Center for Interactive Spaces has together with Bang & Olufsen researched into alternatives to the traditional application of IT in the home.

Gesture-based remote control by means of a single button. This can be used to control a nearby device and to carry e.g.a digital film from one device in the living room to an other device in the kitchen.

For two weeks in February 2006 a family from Gram took part in the iHome project as a test family.

The project was run in collaboration between Center for Interactive Spaces and Bang & Olufsen. Different Prototypes developed in the project were installed into the family home. These included an interactive table with support for true multiple-user interaction.

The table turned out to have a positive effect on a number of the activities performed by the family. It was used, among other things, for the joint planning of holidays. And as something quite out of the ordinary, the family's teenage son and his friends gathered around the table, even though there were other family members present in the kitchen.

For Marianne Graves Petersen, Research Associate Professor at the Department of Computer Science, this is an example of how IT in the home can contribute to support the social life of the family.

"Much of the technology that is being developed for the home still bears the mark of its legacy from the computer as a tool used to increase efficiency and to rationalise. However, with its positioning within the home, its size and the opportunity for true multiple-user interaction, the interactive table turned out to be so attractive that the teenage son could be tempted to place a greater part of his social life in one of the family's shared spaces", she says.

The body needs to be involved

The interactive table and the experimental setup with the family in Gram was just one of many other activities of the iHome project. Another was the development of a prototype for a single button movement-based remote control, which could be used, among other things, to select music and increase and decrease the volume. The development of the remote control actually precedes Nintendo's remote control for Wii, and reflects another important basic concept of the iHome project.

"A lot of IT is developed and implemented as if the body has been dismantled, and all that remains are a few fingertips used to press buttons", says Marianne Graves Petersen and continues,

"In our work at the centre we are very focused on interaction being an experience, and not just an efficient means with which to perform a specific action. This is where the body comes in. It is important, especially in the home, that the body is included, since in reality the home is a very physical place.

Aesthetic interaction

During the iHome project a need arose, according to Marianne Graves Petersen, to define new interaction ideals. As an antipole to the tool-based approach, she, together with her colleagues at the centre, therefore developed the theories of "aesthetic interaction".

"When we speak of aesthetic interaction, we use - as our starting point- the branch of aesthetics that is known as pragmatic aesthetics. This means that we can have experiences from our very association with and use of the interactive objects with which we surround ourselves in our everyday lives. If we ensure that the whole body and all of the senses become involved", she says.

Multiple-user living room table based on the MultiLightTracker technique for tracking luminous pens of different colours. Up to five people can each be given a pen and work together around the table.

In the work on IT in the home we are also very much aware of the fact that technology does not fundamentally change the life that was previously lived in the home. Therefore, a vital part of a development project is the studies of Behavioural patterns in the home, for example, that precede the first outlines for the prototypes. This is where the centre's interdisciplinarity typically comes into play by involving ethnographologists or psychologists in the initial studies.

"We continually try to develop something that is relevant. Therefore, it is vital that we as part of a project such as iHome gain an insight into the mechanisms that are at play in the home. The aim is of course for people to be able to live the lives they want to live. So we have to see whether what we create affects them in positive or negative ways", says Marianne Graves Petersen.

Home Is Where You Are

The collaboration between Center for Interactive Spaces and Bang & Olufsen has, according to Marianne Graves, been very fruitful, but has also offered some challenges.

"It is self-evident that in these types of projects finding the balance between prototypes that primarily support purely research-related aspects, and prototypes that have the potential to be developed into real products can present a challenge", she says.

However, the success of the collaboration is reflected by the facts that Center for Interactive Spaces and Bang &Olufsen have launched a new joint project: "The Mobile Home Center – Home Is Where You Are". The project has received DKK 10 million in support from the Danish National Advanced Technology Foundation, and is now one year into the three years that have been allocated. During the project focus will be placed on infrastructures and interaction methods that can provide the modern, mobile person with ways with which to create a connection to the home.

Being true to the centre's working methods it has been studied, in collaboration with an ethnographer, how, for example, business people, who do a lot of travelling, try to create a connection to the home universe. When we have gained a picture of this, we will start to think in the concepts and tangible prototypes that can support the desire to make a hotel room "more like home", for example.

Center for Interactive Spaces has received good response to its work on IT in the home from the research environments.

> "A lot of IT is developed and implemented as if the body has been dismantled and all that remains is a few fingertips used to push buttons"

"There are of course others who are working with the same themes, but I believe that we are very good at it. We distinguish ourselves from other research environments by our very close collaboration with the people who we call users. And with our focus on interaction as an experience that supports the social, collaborative and playful sides of people. Furthermore, it is a strength that we do not only outline things, but actually build some really good prototypes", she says.

Read more about Marianne Graves Petersen's interactive beanbag "Squeeze" on page 5

The interactive floor

makes you feel like learning

The IT research supports new learning styles. The interactive floor the Wisdom Well motivates tactile-kinaesthetic children to learn.

BY STIG ANDERSEN / PHOTO: INTERACTIVESPACES.NET

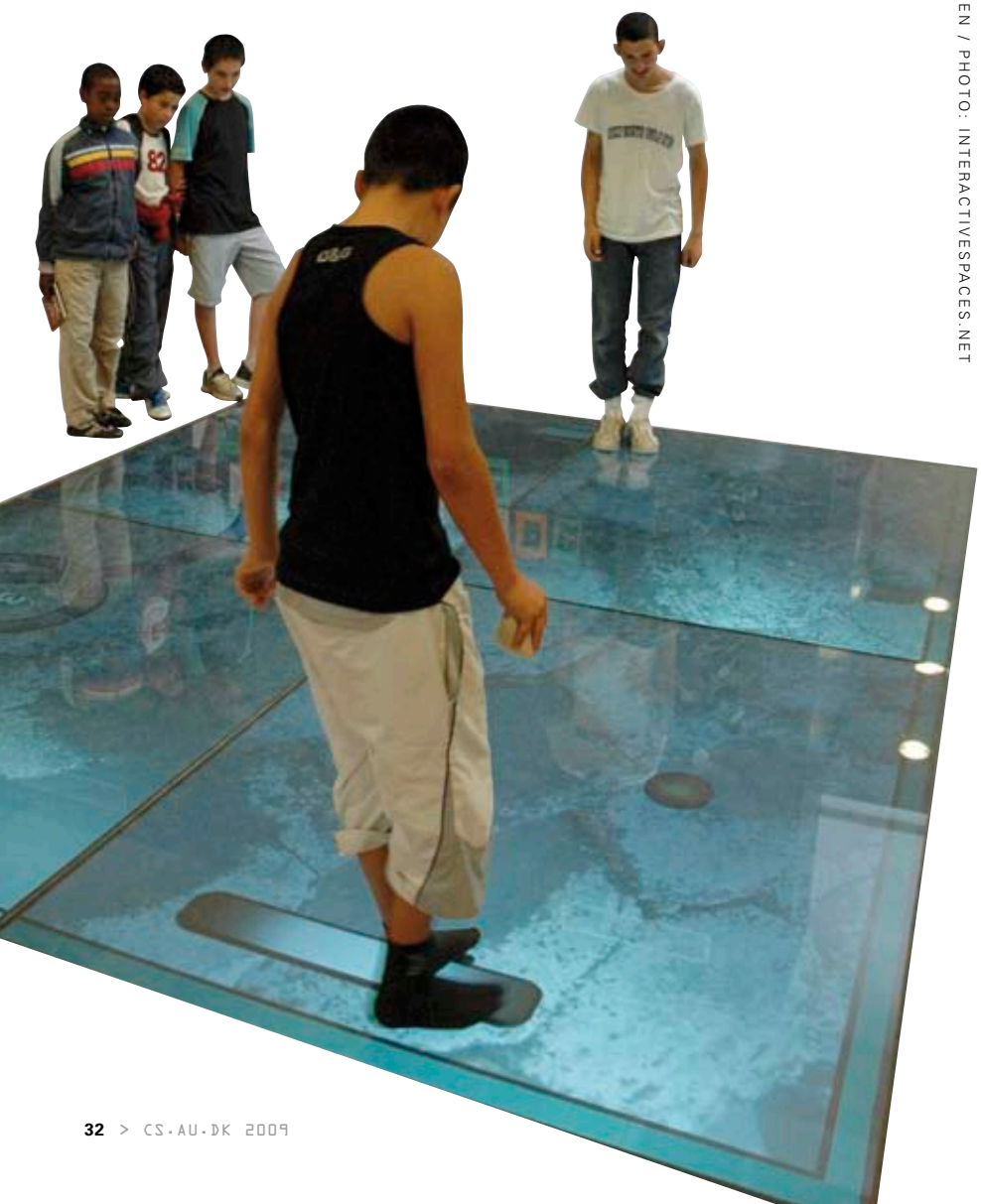
In January 2003 the Møllevang School in Århus partially burned down as a result of a deliberately-started fire. Therefore the school had to be restored and some parts completely rebuilt. And even though this was a depressing situation, an opportunity presented itself for a completely new way of thinking with regards to the physical boundaries of teaching. One of the results was an interactive floor – the Wisdom Well – where the pupils use their bodies to learn.

The messages received from the pupils are unmistakable. As one pupil from the eighth grade expressed", It's more fun on the floor and you get to use your body. You learn something else. You feel like learning".

Karen Johanne Kortbek, MA in Art History and Multimedia and today a PhD student at the Department of Computer Science was involved in the project from its inception and used it as empirical data in her thesis on the body as an interaction device also called "kinaesthetic interaction". She says, "Over the last few years, people working within interaction design, computer game design and design of experience-orientated IT have discovered that mice, keyboards and joysticks are not the only devices that can be used as input devices. With todays growing interest in experiences within many domains, interaction using the whole body has become an important factor.

Your body allows you to learn

Seen in a broader perspective the statement on the Wisdom Well made by the eighth grade pupil is completely in line



Pupils at the Møllevang School are busy with the quiz "Stepstone" at the Wisdom Well. Several answers per question will be marked and the whole body will come into play.

Kaj Grønbæk and Karen Johanne Kortbek received the prestigious Red Dot Best of the Best Award in the category Design Concept on behalf of the Center for Interactive Spaces.

with the research that is being conducted into kinaesthetic interaction.

"An experience seems more current and tangible when the whole body is in play than when the user is only experiencing through finger movements via a mouse behind a traditional desk-bound computer screen. This is why it is quite simply more fun and motivating in itself to learn something via an installation such as the Wisdom Well", says Karen Johanne Kortbek.

"Mice, keyboards and joysticks are not the only devices that can be used as input devices"

In recent years there has been a lot of focus on different learning styles, and it has been shown that the so-called "tactile-kinaesthetic children" learn more if their bodies are involved in their teaching. Here the Wisdom Well is an obvious supplement to the other teaching. The project was based on the iFloor prototype, which the Center for Interactive Spaces had created together with Århus Central Library. Computer scientist Kaspar Rosengreen Nielsen, who has also been involved from the start, says, "The interactive floor in the Central Library was powered by ceiling-based camera tracking, however, since the Møllevang School was to be rebuilt, we were allowed to excavate a hole and attempt the tracking from below.

Capital cities, foods and geometry

Four applications resulted from the project: iFloorquest, where four pupils at a time can put their knowledge, for example of European capital cities, to the test, Stepstone, which is also a game for four, where the participants must use their whole bodies to mark several answers to the same question, for example, which of the displayed foods is healthy and Pong, which is a more classic video game for break periods. The latest addition is Geometrix, where the pupils use their bodies and together solve geometric tasks on the floor, which displays a grid in the style of graph paper. With iFloorquest and Stepstone students and pupils can create new games using the applications, which is one of the major advantages of the Wisdom Well according to Kaspar Rosengreen Nielsen. "Besides involving the whole body in the learning process, the Wisdom Well also prepares the ground for pupil-to-pupil learning. The pupils formulate questions and answers on a PC, send the game to the Wisdom Well and then they or their classmates can move around in the game that they have just created. This has proven to be very motivating in itself", he says.

Challenges and surprises

The Wisdom Well has now passed the prototype stage and the students at the Møllevang School can now broadly deal with the daily support themselves.

"An experience seems more current and tangible when the whole body is in play"

As with all other projects there have been a number of surprises and challenges along the way. For example, it proved very quickly that it was vitally important to develop an offline version of the Wisdom Well so that the teachers could prepare teaching on the Wisdom Well at home. And there have been technical challenges, including the camera tracking from below. This is based on shadows and in the Stepstone game the players could sometimes make shadows with their bodies in such a way that it was difficult to identify what had been chosen. And according to Karen Johanne Kortbek it has been a challenge in itself to design the applications for the Wisdom Well so the whole body comes into play.

A light solution

The Wisdom Well has shown its sustainability, hence the concept is being expanded further. Kaspar Rosengreen Nielsen and his colleagues at the Center for Interactive Spaces are working on the development of a light version to be operated with a ceiling-based projection. A version of the Wisdom Well that requires digging is an expensive solution. Therefore if it is to be placed on a larger market, it will be necessary to be able to supply the less expensive ceiling-based solution.

Integration with existing applications, such as Google Earth are also being considered. Allowing pupils to zoom into New York where they could explore the city streets, would certainly be a fun way to get to know New York.

According to Karen Johanne Kortbek, the Wisdom Well has a number of limitations within the framework of the present implementation:

"Currently there is basically no third dimension in the Wisdom Well. The camera tracking is in 2D and in order to include the third dimension when, for example, tracking the participants' hand movements, it will be necessary to bring other technologies into play", she says.

Besides any further development of the Wisdom Well, the Center for Interactive Spaces would also like to secure funds for an actual scientific study of the learning effect of the Wisdom Well compared with other known methods. There have been a number of positive qualitative evaluations of the Wisdom Well as a pedagogic tool, so it is now relevant to conduct a longer-term study of the effect.

Programmes

at THE DEPARTMENT OF **COMPUTER SCIENCE**

BY MARIE RØRDAM FENGER / PHOTO: SARA KANGAS

IN TWO YEARS THE DEPARTMENT OF COMPUTER SCIENCE HAS DOUBLED ITS STUDENT INTAKE, AND IN 2008 THE DEPARTMENT WAS THE LARGEST DEPARTMENT WITHIN THE FACULTY OF SCIENCE, MEASURED IN THE NUMBER OF NEW STUDENTS. CURRENTLY A QUARTER OF THE FACULTY'S NEW STUDENTS ARE COMPUTER SCIENTISTS.

On the following pages you can read about the reformation that the study of computer science has gone through over the course of the last five years and about the new programme in IT.

The approximately 1135 students within the Department of Computer Science are divided into two BSc programmes, a MSc programme, a MEng programme, a Master's programme, a Diploma programme and a PhD programme:

The Bachelor programme in Computer Science:	316 students
The MSc programme in Computer Science:	187 students
The Bachelor Programme in IT:	87 students
The MSc programme in Technical IT:	76 students
The PhD programme in Computer Science:	61 students
The Diploma programme in Software Design:	180 students *
The Master's programme in Software Design:	228 students *

*Number of fee-paying students. Since the same person may pay for more than one programme in a calendar year, the actual number of students will be lower.

The **educational reformation** of computer science

IN 2003 THE FACULTY OF SCIENCE INTRODUCED A MAJOR CHANGE TO THE AREA OF EDUCATION: SEMESTERS WERE REPLACED BY QUARTERS. A TOTAL REFORMATION HAS BEEN IMPLEMENTED AT THE DEPARTMENT OF COMPUTER SCIENCE, WHICH HAS RESULTED IN, AMONG OTHER THINGS, AN INCREASED PROFESSIONALISATION OF THE EDUCATION OFFERED, AND A GREATER AWARENESS OF THE GOALS AND MEANS OF THE TEACHING", BELIEVES MICHAEL SCHWARTZBACH.

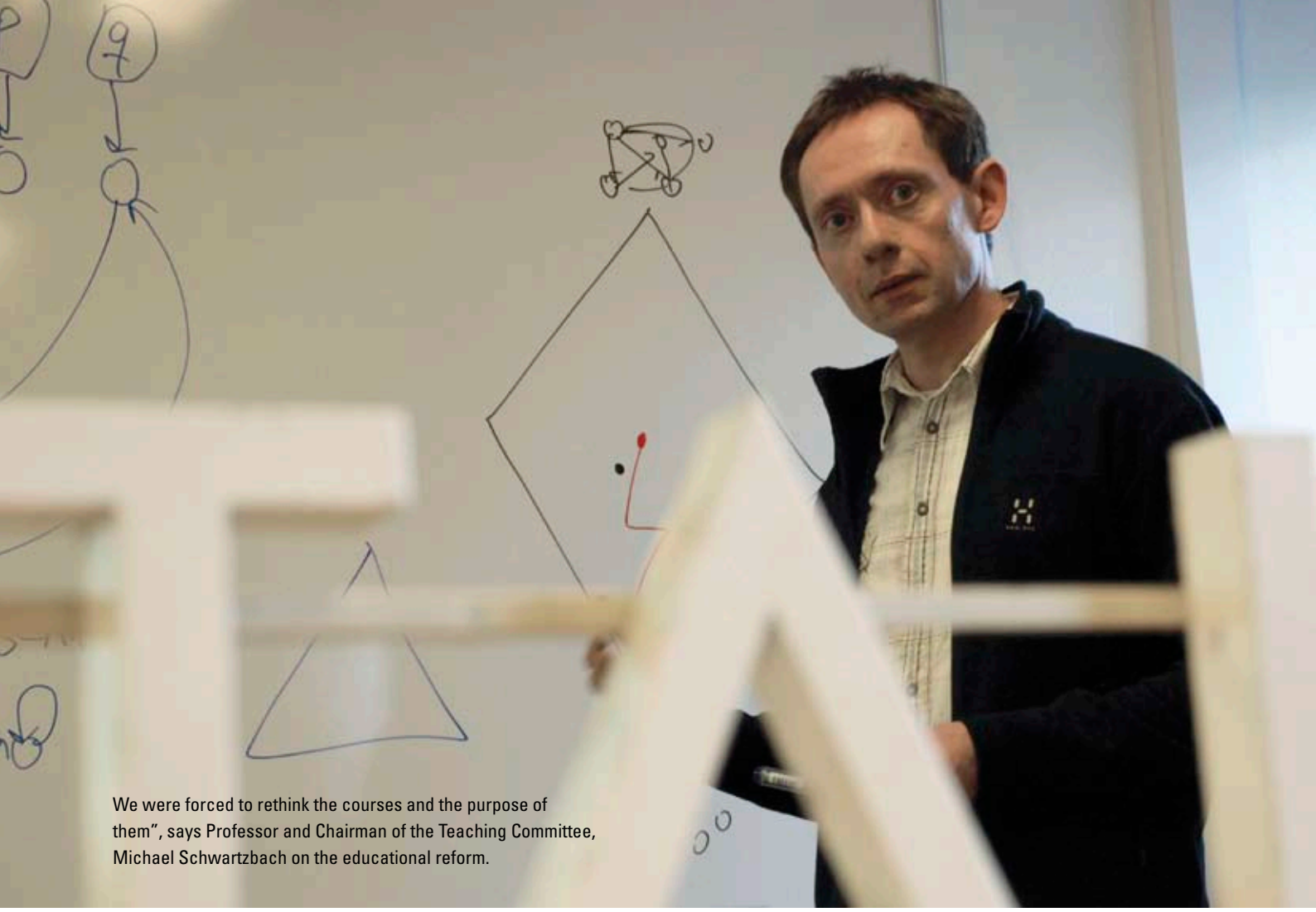
BY MARIE RØRDAM FENGER / PHOTO: SARA KANGAS

Examinations are no longer an event, they are a state of being. This is how Professor Michael Schwartzbach describes the reality that the students at the Department of Computer Science are now encountering in addition to the changes that the computer science programme has undergone. Just seven weeks after the new students have embarked upon their studies, they are examined in their first subject. "In this way the studies become more manageable for the first years of study and the examination burden more bearable, increasing the number of graduations", says Michael Schwartzbach, comparing the situation with his own period of study, where he after the first year had to pass the broad omnibus subject 'Computer Science 1', and after the second year 'Computer Science 2' and so on. "At the end of the teaching year we would take our exams in the summer and hope that we had learned something", says Michael Schwartzbach. The consequences of the Faculty of Science deciding in 2003 to reorganise the teaching structure are that all of the courses now last for seven weeks instead of the previous fifteen weeks. This is the reason why the examination periods have consequently increased to four times a year. After one year the new students have already attended 12 examinations.

Greater awareness

With the reform the faculty made higher demands on the course descriptions in order to provide greater clarity for the students as to the content of the various courses and the competencies that they would acquire after having completed the courses. "We were forced to rethink the courses and the purpose of them", says Michael Schwartzbach, who does not consider the extra work that this produces a burden; on the contrary, according to him it has provided the lecturers with a greater awareness and reflection, which has increased the transparency of the courses. The same applies to the examination forms, which have also been reformated:

"We continually ask ourselves: Are we able to measure what we teach? It is of course not enough to just vary between written and oral examinations, as we did



We were forced to rethink the courses and the purpose of them", says Professor and Chairman of the Teaching Committee, Michael Schwartzbach on the educational reform.

previously, as we cannot be sure whether we can test the students in the specific tools that they have learned in a specific course in this way. Among the examination forms that the lecturers at the Department of Computer Science are developing

> "After one year the new students have already attended 12 examinations"

are portfolio examinations, group projects and multiple choice tests. The examination forms must support the learning goals of the course", says Michael Schwartzbach. The examination form is stated in the course description and approved by both the teaching committee as well as by the faculty.

Individualised and streamlined coaching

Previously teaching assistants (who are responsible for the practical sessions where students can work on subjects and methods that they have learned in their lectures) were primarily Master's students, whereas today they are almost exclusively PhD students. This is because there are many more PhD students than was the case just five years ago", says Schwartzbach. At this time there were 2-3 per year group, as opposed to today where around 15 percent of a year group starts on the research programme.

"Nor are the practical sessions just as they were in the "old days", as Michael Schwartzbach referring to the time before the computer science educational reform. Previously practical sessions tended to be three comfortable hours with coffee and cake and people dozing off on the

> "Previously practical sessions tended to be three comfortable hours with coffee and cake and people dozing off on the back row, today it's a completely different kettle of fish"

back row, today it's a completely different kettle of fish. For example a project group can book "coaching" by a student assistant, who then allocates half an hour for the specific problem facing the group. "This of course forces the students to be extremely well-prepared in order to gain something from the coaching", believes Michael Schwartzbach, who also mentions web boards, another type of assistance that the students can turn to. Web boards are staffed by teaching assistants. The Web boards are at times also active at night, due to the offbeat daily rhythms of both the students and teaching assistants", he says.

Room for improvement

Even though Michael Schwartzbach generally points towards a lot of positive changes in the study structure, there are still a few points where there is room for improvement. In 2008 a workplace evaluation of the scientific study environments of the different departments was drawn up. The study showed that the programmes in the Department of Computer Science worked well in all of the mechanical areas, such as teaching, examinations, etc., but the computer science study environment was not awarded top marks by the students. Concepts such as bullying, exclusion and loneliness figured higher than the Educational Committee had hoped", says Schwartzbach:

"And it was actually quite difficult for us to proceed with the study. What exactly is "bullying" and how should "loneliness" be interpreted? We can come up with all possible hypotheses that can explain this and that, but this does not bring us any closer to the root cause", he says. The Educational Committee therefore took the initiative to conduct a major and tailor-made study of the study environment at the Department of Computer Science. A psychologist has therefore been engaged and will be involved in the design of a broad questionnaire survey, which should indicate what tendencies to work with. The psychologist will then get hold of a number of students on the basis of the survey results and ask more in-depth questions into the problem areas. "We are interested in finding out what characterises the department and our students and whether they should be treated differently than other students", stresses Michael Schwartzbach, who hopes that the department by taking the matter seriously can eradicate some of the problems.

High enrolment figures

Nevertheless, things are going well at the Department of Computer Science. Even though almost all long higher educations experienced a fall in applications in 2008, a total of 166 students enrolled in the department that year. This is an increase of 84 students since 2006 and means that the computer science students constitute 24% of all students in the Faculty of Science. This increase was partly due to the new programme in IT, to which 50 students enrolled in 2008, but the basic programme in computer science can still boast at having attracted 34 more students in 2008 than in the preceding year. However, Michael Schwartzbach prefers not to comment on the reason behind the large number of applications: "We promised ourselves that we wouldn't try to explain the good figures, as we cannot show for certain whether our branding of the programmes, recruitment from primary and lower secondary and upper secondary schools or a general focus on IT are the reasons" he says and continues: "However, something clearly works and this naturally makes us want to continue along the path that we are walking".

Computer science

in a new way

THE BACHELOR PROGRAMME IN IT IS THE LATEST ADDITION TO THE EDUCATIONAL PROGRAMMES OFFERED BY THE DEPARTMENT OF COMPUTER SCIENCE. THE PROGRAMME WILL EQUIP THE STUDENTS TO COMBINE COMPUTER SCIENCE, PRODUCT DESIGN AND BUSINESS UNDERSTANDING.

BY MARIE RØRDAM FENGER

At a 2006 conference on the global challenges facing IT programmes the Science Minister, Helge Sander, expressed his concerns about the future of the IT industry. He made it clear that Denmark should rethink its IT programmes to remain strong. "IT programmes must quite simply be made more attractive to young people and more targeted towards users. It can for example be achieved by combining IT with other subject areas" the Science Minister proposed. The Department of Computer Science reacted swiftly and shortly afterwards offered a new programme, which combines computer science with product design and business understanding.

> "IT programmes must quite simply be made more attractive to young people and more targeted towards users. This can for example be achieved by combining IT with other subject areas"

PHOTO: SARA KANGAS

Bridging computer science and the business world

The programme is in its second year and in September 2008, 50 new students were enrolled.

The Bachelor programme will equip the students to combine computer science, business and product design", says Søren Poulsen, manager of the programme.

The IT students show their perceptions of how future electronic newspapers will look

PHOTO: SØREN POULSEN

> "Our new programme in IT focuses on product development, the integration of IT into software, hardware and product design-related areas"

"Our new programme in IT focuses on product development, the integration of IT into software, hardware and product design-related areas. This is the trinity that constitutes the programme and will equip students to be able to create bridges between computer science and the business world." states Søren Poulsen, Manager of the Programme in IT. In 2006 he was appointed to expand awareness of the programme to both potential students and the IT sector. One of the ideas behind the programme is to have strong links with the business world; this is why we have added internships and student job with potential recruiting companies during the course of the programme. "The involved IT companies have shown a lot of interest in the competencies that the students will acquire via the programme. They demand the very computer science competencies that we already deliver in our existing programme in computer science, but the development of product design and business skills meets the current need with fair precision" says Søren Poulsen. However, the programme in IT is not as broad as it may sound for a traditional computer scientist. On the other hand, it is a specialised programme in which the student selects from one of three specialisations: software development, product design or business understanding. Two of the specialisations, product design and business understanding are offered in collaboration with Aarhus School of Architecture and Aarhus School of Business to reinforce the technical content of the specialisations.

Application-oriented students

At the end of the first year, the students were given the task to devise and present their perceptions of how future electronic newspapers will look. "We were very impressed with the results of the cross-disciplinary challenge, says Søren Poulsen. "The good thing about the programme in IT is that the students learn to think in whole products, to think these through to completion and to think commercially. A Master's programme in IT is also being prepared and it is expected to be ready in 2010.

CONTINUING EDUCATION AT THE DEPARTMENT OF COMPUTER SCIENCE IS RUN ACCORDING TO THE SUPERMARKET MODEL: YOU CAN PICK AND CHOOSE. COMPUTER SCIENTISTS CAN ENHANCE THEIR COMPETENCIES ACCORDING TO THEIR NEEDS AND INTERESTS

You can PICK AND CHOOSE

BY ARNE VOLLERTSEN

PHOTO: LARS KRUSE, AU FOTO

Henrik Bærbak Christensen, Associate Professor and Head of Continuing Education at the Department of Computer Science is lecturing in "Programming of large object-oriented systems". The course has run since 1999 with more than 300 students.

Academic input is not the only thing students get out of a course. A lot of contacts and networks to colleagues in other companies can be made during the breaks.

The teaching is a mix of group work, discussions and lectures, which allows students to get to know each other by working closely together.

The majority of our students have short-term educations and come here to enhance their qualifications. However, we also have a lot of fully-fledged computer scientists who come here to concentrate on subjects that they feel were not sufficiently dealt with during their study time. We would really like to have more students like these", says Henrik Bærbak Christensen, Associate Professor in Computer Science and Head of the Department's Continuing Education activities.

Popular qualification packages

As has been stated, students are free to pick and choose, but the most popular computer science qualification packages focus on XML and Internet and software architecture. There are not quite as many applications for e.g. IT Security and Software Testing subjects. The teaching takes the form of seven hour seminars on Saturdays. Everything is arranged to be a mix of lectures and group work and the size of the classes varies between 12 and 35 people. Occassionally a sought-after XML course will have a total of 50 students. "And the breaks are unbelievably important", says Henrik Bærbak. "The breakfast and coffee breaks are diligently used to network. Students often tell me that they make a lot of contacts with colleagues in other companies, which they can use later on. The students are committed and there is a good atmosphere and a great desire to discuss and share experiences", says Henrik Bærbak. "In addition to this, we have a low drop-out and failure rate due to the fact, among other things, that we are very flexible. If, for example, an examination is to take place while a student is on a course in the USA, we will find a new date for his exam."

Interuniversity collaboration

The Continuing Education at the Department of Computer Science is organised in collaboration with IT University West, an umbrella organisation that co-ordinates and markets IT programmes at the universities of Aarhus, Aalborg and southern Denmark, including the School of Business at Aarhus University. This means that students can pick and choose courses in Århus, Aalborg and Odense without any problem. Besides the popular courses in XML and Internet and software architecture, there are a large number of applications for courses in IT and Organisation, offered by the School of Business and courses in databases and embedded systems, offered by Aalborg University.

> "Lectures and examinations are arranged to fit in with people's fulltime jobs"

Get an overview of the courses on offer at **www.itev.dk**

FEES:
DKK 4,000 per single subject
DDK 12,000 per qualification package (contains three single subjects).
A single subject consists of three seminar days, Typically scheduled for Saturdays and less commonly on Fridays for a period of 7 weeks.

"We cannot combat crime if we do not understand the systems"

Michael Lind Mortensen, owner of Aconiac Security Group

Michael Lind Mortensen, who is a computer science student and owner of Aconiac Security Group, is convinced that the ideal company constantly has links with universities.

PHOTO: MICHAEL LIND MORTENSEN

Exceptional
Entrepreneurial Drive

The entrepreneurial drive among computer scientists at Katrinebjerg is high. This is confirmed by an entrepreneurial study conducted by the communication office at the Alexandra Institute.

BY MARIA ØSTER

This high level of entrepreneurial drive pleases Søren Poulsen, Manager of the IT Bachelor programme at the Department of Computer Science. "Innovation and entrepreneurialism in IT are absolutely essential in order for us to maintain a dynamic and progressive innovation environment here in Århus, he says and adds, "The high level of entrepreneurialism also demonstrates a high level of commitment to the subject area of which the students are a part, and we are very pleased about that.

Own company

Michael Lind Mortensen, 21, is studying Computer Science and is in his third semester. Together with four other students he has set up his own company, and he finds this job far more interesting than being employed as a student assistant in a large company. "In a student job you will often have to carry out tasks that are not very challenging. In your own company you can design your own procedures. You are your own boss and design your own fortunes, so to say", he says. Aconiac Security Group, as the company is called, can be found in InnoCamp, and the facilities can be used by entrepreneurial students at Katrinebjerg. Center for Entrepreneurship offers entrepreneurs coaching and assistance in establishing contact with the business community. Aconiac is involved in IT security solutions, and its tasks include server configuration and security testing. "A number of us have an insight into the criminal IT hacker environment. We know how to break into the systems, and the motivation for starting the company was therefore to work against the criminal environment. We are also interested in political matters, and in different ways we try to influence bodies that have influence on case law and legislation relating to IT criminality. We are also motivated by the opportunity to change the status quo", goes Michael's motivation. However, Michael does admit that when you run your own business, you work for many hours, "It's a certainty that if you want to be an entrepreneur while studying, you will not have much time for anything else. Generally, sleep will be the first thing that you cut down on", Michael laughs and continues; "I think that most of us sleep about five hours a night."

Usable knowledge obtained

The entrepreneur study shows that the majority of start-up companies are based on the knowledge that students acquire during their studies. Michael emphasises that it is advantageous to have a company linked to the university. "We learn a lot of things at the university that we can use in our company. From computer science we acquire theoretical knowledge and a greater understanding of the systems that we work with within IT security. A hacker cannot exploit a system if he does not fully understand the system. They understand the systems to such an extent that they can make the systems act in ways that they are not designed for. Therefore, we cannot combat crime if we do not understand the systems. This is why instruction in, for example, machine architecture, operating systems and programming gives us a good foundation and develops our knowledge", he explains. Michael believes that Aconiac will continue as a business when he has completed his studies. However, he believes that it will be in another form, since the company is in a state of constant development in the innovative environment at Katrinebjerg. "We want to develop constantly. This is one of the very advantages of being a university company: We develop because we are continually being challenged by the university, and because we are in a very dynamic environment. There are always people to spar with, and we can get the most up-to-date knowledge from areas that will not be adopted by the business world for some time. Aconiac is in this way an innovative enterprise, which quickly develops both its knowledge and competencies". "It is our sincere belief that the ideal company has constant links with a university", concludes Michael. A smaller proportion of companies continue as independent businesses when the students have concluded their studies. However, this does not worry Søren Poulsen, Manager of the IT Bachelor programme at the Department of Computer Science. "When our students graduate, many decide to look for a job within an established company, and this is quite understandable. We are just glad that all of the entrepreneurs will be able to draw from their experiences in their future employment", he explains. "This will equip them with an innovative mindset, which will be of great benefit to their Employers.

www.aconiac.dk

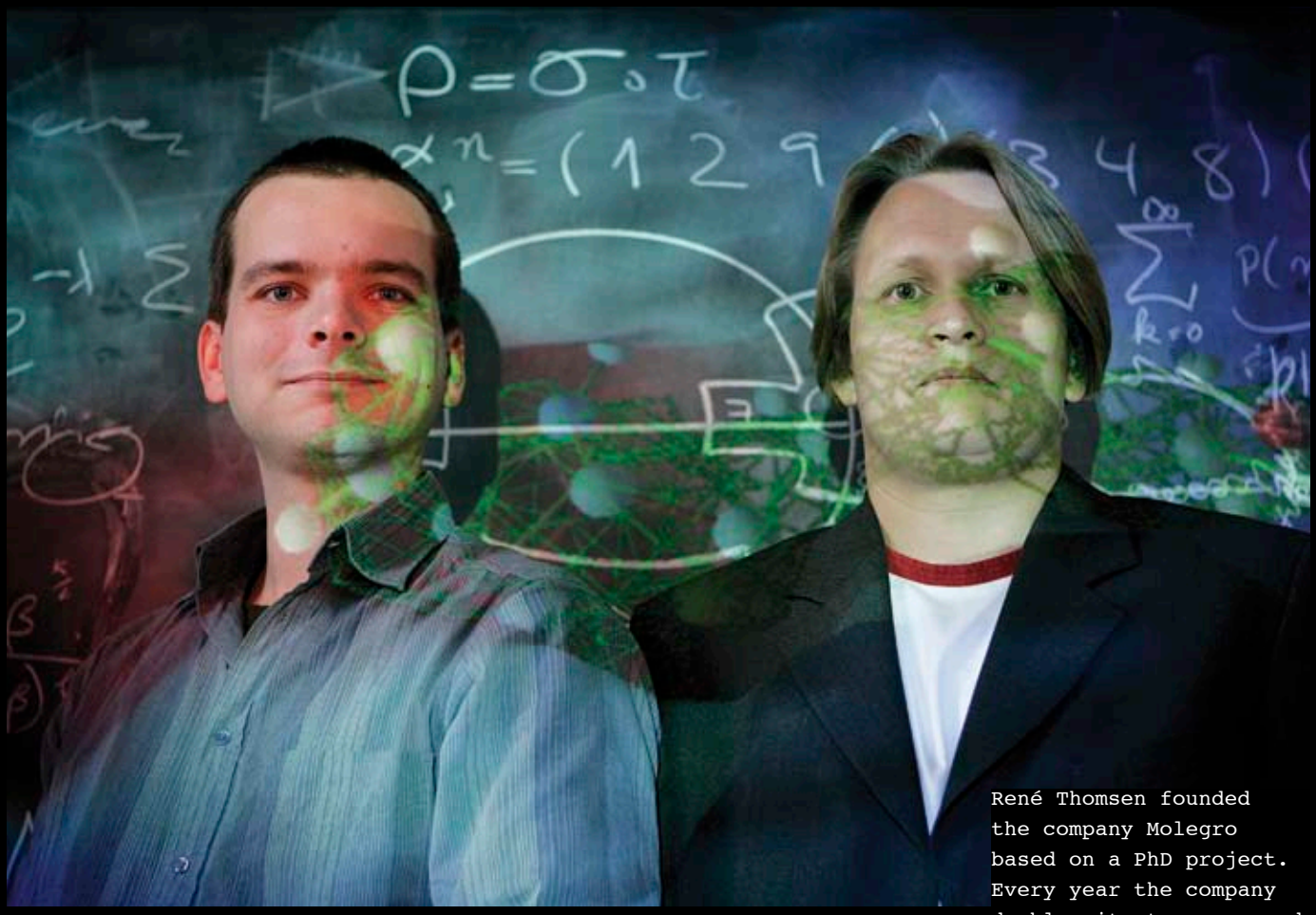


PHOTO: CHILI FOTO & ARKIV: JENS HASSE

René Thomsen founded the company Molegro based on a PhD project. Every year the company doubles its turnover and its two partners are now focusing on expanding their workforce.

"We believed that due to the quality of our technology, our products would market themselves. In reality, it is much more complicated than that"

The founders of the company Molegro Aps are among some of the entrepreneurs who decided to continue with their project after their graduation. The company, which is involved in "molecular docking", originated from a PhD project at the Department of Computer Science.

From Phd to international enterprise

BY MARIA ØSTER

When René Thomsen set up Molegro in 2005 together with his friend from his secondary school days, Mikael Christensen, he had scarcely dreamed of it becoming an international enterprise. René has a PhD in Computer Science, with a focus on optimisation algorithms and bioinformatics, while his colleague Mikael is a physicist. Today they collaborate with a number of Danish research institutes such as BiRC at Aarhus University, University of Copenhagen and DTU. They also have contact with international pharmaceuticals companies and their client list includes companies and institutes in Japan, the USA and large parts of Europe.

Long process

"It's enjoyable being independent because you are so freely positioned. And it's motivating to work with the research-based part at the same time as developing products that are actually used in the real world", explains René. However, the entrepreneurial life is hard work and running your own company is a very different matter to being a technical expert: "We believed that due to the quality of our technology, our products would market themselves. In reality, it is much more complicated than that", grins René. From the establishment of the company in 2005 an up to the present time, the process of market entry has been a long one. The two software developers quickly realised that they themselves could not attend the selling of the product. This is why they now use global distributors who take care of the selling of Molegro's software. The two friends are now about to make a living from the project. The company is currently placed in leased premises at Aarhus University, where they derive immense benefit from being part of the research network.

3D modelling for the pharmaceutical industry

Molegro is specialised in developing software for "molecular docking". This is a 3D simulation of how a pharmaceutical interacts with different proteins in the human body. The software can be used in the initial stage of the production of pharmaceuticals and can predict their effects on the body. "Our programs are used in the start phase to locate promising pharmaceutical candidates. These can then be further worked on in the laboratory", explains René. The programs therefore act as supplements to costly laboratory experiments and this means that the pharmaceuticals companies can save time and money in the development of pharmaceuticals.

Additional colleagues

Until now Molegro has only had two employees, the two owners of the company. Accounting and sales are outsourced. However, René says: "We would like to have additional colleagues and we could easily use chemists, programmers and marketing people. Our turnover doubles every year and during the course of next year we expect to have adequate liquidity activity. So we envisage being able to employ a couple of colleagues", concludes René. The two researchers themselves own two-thirds of Molegro, while Østjysk Innovation, as co-owner has injected DDK 1,5 million in the form of venture capital into the project.

www.molegro.com

SIMAP

THE MAJORITY OF COMPUTER SCIENCE RESEARCH PROJECTS HAVE A TANGIBLE APPLICATION PERSPECTIVE. SOMETIMES THE PROJECTS END UP AS RESEARCH-BASED COMPANIES. READ HERE ABOUT THE CHALLENGES MET BY THE RESEARCHERS AT THE DEPARTMENT OF COMPUTER SCIENCE WHO SUDDENLY HAVE TO JUGGLE PRODUCT DEVELOPMENT, CLIENT NEEDS AND LIQUIDITY AND THE BENEFITS OF BRINGING A THOROUGHLY-TESTED AND RESEARCHED PRODUCT INTO THE MARKET.

Advanced cryptology ensures complete confidence when sugar beet quotas are up for auction. The solution developed for Danisco is now on its way to a larger market.

This is not a problem that most of us think about when we eat a cake made with sugar from the Danish food giant Danisco. However, when the company arranges auctions on the Internet, where sugar beet quotas change hands for hundreds of thousands of Kroner, it is actually of vital importance that each bidder can be certain of complete confidence. The aim of the auction is to achieve the price that reflects the actual supply and demand. And if individual bids were to be known, you would run the risk of tactics being employed in the auction. In the SIMAP (Secure Information Management and Processing) project, the Department of Computer Science and the Center for IT Security in collaboration with the Institute of Food and Resource Economics, the University of Copenhagen, Danisco, IBM and Lauritz.com have developed a system that ensures the highest level of confidence for all interested parties in the auction. Technically, this means that as soon as a sugar beet producer sends in his bid from his PC, it is encrypted and remains encrypted throughout the entire auction.

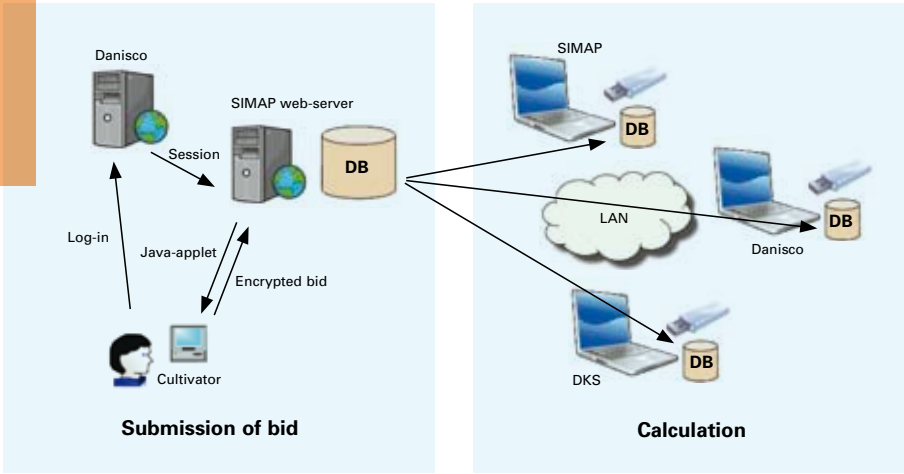
"A solution looking for a problem"

In addition to ensuring the correct price for the sugar beet quotes, the system also ensures the best possible utilization of the sugar beet quotas that is available. For Danisco, which pays for the auctions and which purchases a large proportion of the Danish sugar beet production, this is a very important financial incentive. Jakob Illeborg Pagter, Innovation Director at the Alexandra Institutes, says: "At the start of the project there was a certain element of "a solution looking for a problem".

Cryptology meets sugar beet quotas

BY STIG ANDERSEN

The aim of SIMAP is that an auction achieves the price that reflects the actual supply and demand. If individual bids were to be known, you would run the risk of tactics being employed in the auction.



There was some very advanced cryptology available and we considered the possible applications of this. Since the challenge of achieving the correct result, without all intermediate results being known is an integral part of an auction, this was an obvious possibility. At the same time, from a mathematical perspective, this gave the cryptology group under the leadership of Professor Ivan Damgård the opportunity to work with the cryptographic technique Secure Multiparty Computation in a practical application.

Bold Group

The interdisciplinarity of the development project has, according to Jakob Illeborg Pagter, been decisive in the operation of an effective solution. Not least, the efforts from the economists involved in the project have been very valuable. According to Jakob Illeborg Pagter, the greatest challenges of the project have had nothing not do with the solution itself: "It was a challenge to get Danisco to use the technology in practice to conduct the auctions. However, they have shown great boldness in doing this as we must not forget that despite everything this is relatively untested technology that is being brought into play. Therefore, it was a major challenge putting a system into operation where you are exposed to all possible practical problems of the type: What do you do if the database crashes? Two auctions have been held where the system from the SIMAP project has been used and the experiences have been so positive that the people behind the project now intend to sell the product to other parts of the food industry in Denmark and overseas, where quotes are traded via auctions.

"The solution will be marketed by the company Partisia Market Design, which was founded by twelve people from the original SIMAP project. To begin with, the activities will be conducted within the framework of a collaboration agreement with the Alexandra Institute, which will assist in the development of the business model, administrative duties, construction of the website, etc.", says Jakob Illeborg Pagter.

> "Technically, this means that as soon as a sugar beet producer sends his bid from his PC, it is encrypted and remains encrypted throughout the entire auction"

A good start is half the cost

One of the future tasks will be to create the future financial basis for the newly-started company. It is also the intention here that the Alexandra Institute will assist and provide support. However, there are currently other priorities in this area. "The plan is for us to bring in some additional clients. We must therefore now approach other Danish and overseas companies and organisation that also trade in quotas. And we will be very satisfied if we have two or three auctions in the pipeline for next summer. As regards the financing that we will have to secure at some point, it is important that we first get as much as possible up and running. The longer you are in the start-up, the less time you will spend to secure capital", says Jakob Illeborg Pagter. And he is not nervous about succeeding in finding new clients. "There are loads of potential clients within the food sector. The challenge of confidence faces everybody who deals in quotas, and we actually have a unique and cost-effective solution. As far as we know, there is nobody else who has conducted auctions on the scale that we have conducted for Danisco with the level of confidence that the Secure Multiparty Computation technology can deliver", he says. In addition to systems for Internet-based auctions, the plan is to at some point also use the advanced cryptology in other contexts where it is of vital importance to keep information confidential for the interested parties. This could be in conjunction with e-elections, benchmarking and negotiations. However, to begin with it has to be full steam ahead with sales, so that the solution that has already been implemented can extend further onto the market.

www.partisia.com

43D focuses on both an excellent 3D experience and flexibility in the solution, so that every client have been able to load their own 3D data into the finished system.

PHOTO: 43D

"We started the hard way"

The company 43D creates advanced 3D modelling for the visualisation of planned wind farms and new developments. Ten of the participants of the original research project started the hard way - without external capital.

BY STIG ANDERSEN

In 2003 the EU-sponsored research project WorkSPACE concluded. However, the participants in the project believed that they had come so far in the development of advanced 3D modelling techniques that they could simply not justify letting the project die. All of those involved in the project were given the opportunity to continue in the company 43D and ten accepted. One of them was Preben Holst Mogensen, Associate Professor at the Department of Computer Science and Managing Director of 43D. "In the research project we experimented with new ways of using 3D. And as something new at that time, we worked on physical and digital integration. We ended up with a very good case concerning 3D modelling of planned wind farms in the UK. And this was also the first area that we focused on in 43D", he says.

"A really good 3D experience"

In the UK wind turbines are typically located in large wind farms and there are strict requirements placed on energy companies with regards to visual documentation of the impact of the planned wind farms on the landscape. The Ministry of Defence and the Royal Airforce may also be interested in very accurate 3D visualisations in order to assess the tactical space for manoeuvring when low flying. And 43D has been alone in its ability to provide these visualisations. "There are others who have been working on creating very advanced 3D visualisation, but this has typically been for the purpose of a very specific application, e.g. gaming. We have focused on both an extremely good 3D experience and flexibility in the solution, so that each client are able to load their own 3D data into our system. This flexibility still differentiates us in the market", says Preben Holst Mogensen. As the ten partners had decided to further conduct the activities from the research project in 43d, they decided to finance the continued product development without external capital. "We started out in July 2004 and used the first year to finalise the program. It was important to have something to bring to the market. And we chose to do this the hard way by financing the start-up and development through consulting services. The software was still not sufficiently robust to be released, but we could use it ourselves to complete assignments for our clients", says Preben Holst Mogensen.

> "We could certainly have attracted clients quicker if we had had some capital"

A risky stage

Since the ten partners started the company in 2004, people warned about the pitfalls in the initial phases of the life of a company. And according to Preben Holst Mogensen, all the warnings were confirmed in reality!

"What we did was really hard to do. Ultimately, it proved feasible. However, we could certainly have attracted clients quicker, if we had had some capital. Selling to the type of clients who use our solutions is a very expensive process. However, we were a little naive in this respect. We believed so much in our product that we expected to sell it quickly. A lesson earned is that if you do it from own resources, things will just not happen that fast. But, we are most likely not the only ones to experience this", he smiles. Currently there are eleven partners, and they all have jobs besides their activities in 43D. Depending on the scope of jobs and goodwill of respective employers, they work in the company on a part-time basis. They all still have strong links with the research environment, and this is both a strength and a potential weakness", says Preben Holst Mogensen: "In a company like ours, it is all about what we can sell here and now, and about what we will live off in two or three years. Therefore, in parallel, we have to continually investigate new opportunities to use our research in a product context. And because we are based where we work, we must be careful not to get stuck in pure research..

Ships and festivals

The project @aGlance, in which 43D is a partner, is an example of a new business area that the company may cultivate. Here 43D supplies the basic 3D environment for a system that is used to co-ordinate overviews and emergency planning during large events. The system was used at the Tall Ships' Races in Århus in 2007, and at the Skanderborg Festival in 2008. From focusing on the 3D visualisation of proposed wind farms, 43D is thus in the process of moving into other domains. According to Preben Holst Mogensen the development is heading in the direction of off-the-shelf software with more generic applications. Not least because many more have access to 3D data.

In addition to the challenge of entering into new application areas, 43D also faces the challenge of handling a European market with many languages. The linguistic challenges regards both sales and maintaining several language versions of the software. As such, this is not part of the core technologies, but is part of its context, the totality of which constitutes the product.

www.43d.com / www.aglance.dk

A year ago BalaSuthas Sundararajah decided to focus one hundred percent on transforming the Info-Gallery into a real product. Today InfoGallery is established on the Danish library market and the product development continues.

passion for the product drives the work

BY STIG ANDERSEN

InfoGallery is not yet formally established as an independent company, but instead as a unit within the Alexandra Institute. However, in practice the sales and development activities for the interactive InfoGallery are conducted as a company under standard commercial conditions. The company currently consists of one and a half programmers, a graphic designer, the Product Manager BalaSuthas Sundararajah (Suthas), a computer scientist, employed by the Alexandra Institute and with his technical focus at Center for Interactive Spaces for the past four years. Suthas is a man of many roles: "If InfoGallery were formally a company, I would probably also be the Managing Director, the Sales Manager and the Development Manager", he smiles and continues, "Everything is driven by something that you could almost call a passion for the product. And I try to fulfil various roles, according to what is best for the product. When people like us are constantly in the process of developing and maturing a product and not least to get it marketed, it is vitally important that they have passion, which will actually sacrifice something to promote the product.

Two Master's thesis students and one developer

The idea behind the InfoGallery was originally created in collaboration with two Master's thesis students, Sidsel Bech-Petersen and Anne Rohde, under the supervision of Professor Kaj Grønbæk, Manager of Center for Interactive Spaces. Originally

> "If the InfoGallery was formally a company, I would probably also be the Managing Director, Sales Manager and Development Manager"

the idea was that IT-supported communication could be used more effectively to target information to library users.

At this time Suthas was working the eBag (the electronic school bag) project. However, InfoGallery gradually took up more and more of his working hours and at one point he was the only developer on the project. He realised the great potential offered by the InfoGalleri concept. Last year he therefore decided to fully focus on promoting InfoGallery into an economically sustainable product. "Many people have very good ideas such as InfoGallery. But before your idea can be developed into a modern product you go through a lot of ups and downs. You will typically have such great faith in your idea or prototype that you imagine it being used ubiquitously. However, if you think in this way, the end result will surely be that it cannot be used anywhere. It is very important to maintain your focus", he says.

Business without business plan

InfoGallery is now in use in the largest Danish libraries, including the Central Library in Århus and the Royal Library in Copenhagen. It is also in use in a smaller number of museums, including the B&O Department of the Struer Museum. The next step will be to market InfoGallery to major centres. In addition to having a clear position as to what types of customers it will focus on, InfoGallery does not have an actual business plan. "At the moment we are very focused on building up a business. And formal business plans are not in themselves a guarantee for success. However, the time may be right to set ourselves some more specific goals", he says.

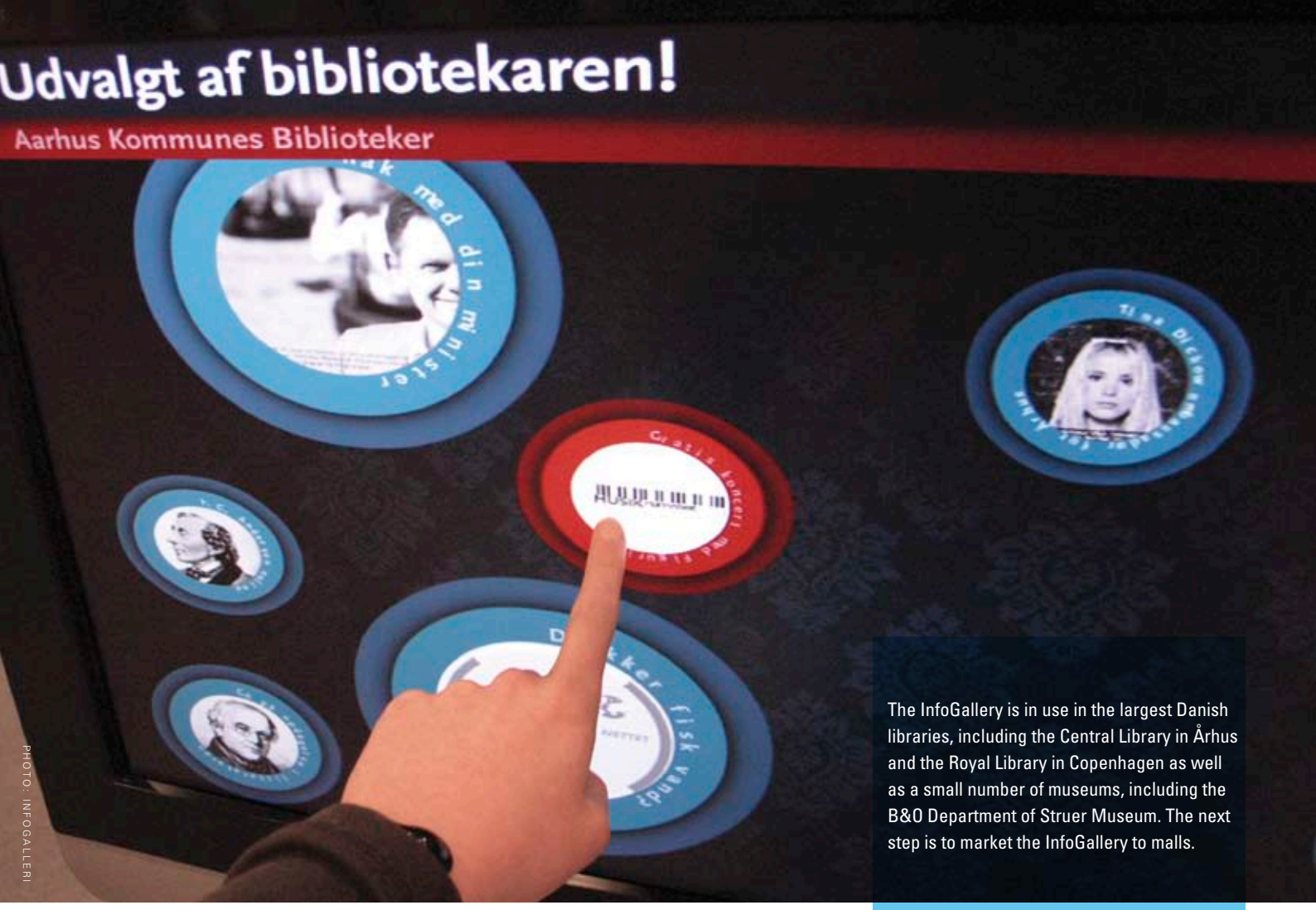


PHOTO: INFOGALLERI

The InfoGallery is in use in the largest Danish libraries, including the Central Library in Århus and the Royal Library in Copenhagen as well as a small number of museums, including the B&O Department of Struer Museum. The next step is to market the InfoGallery to malls.

A number of strategies can be chosen when you move from being a research project to a business. The InfoGallery has adopted the approach which Suthas calls the "small, tough step" before taking the big step of bringing in external investors, the appointment of a profession Board, and everything else associated with a more formal corporate structure. He says, "We have actually been able to finance the development activities and the daily operations through customer-financed projects and our ongoing product sales. And this is of course a major success in itself. Even though we may be working on a day-to-day basis, we naturally do have an overall goal of creating growth and a sound and economically sustainable company in the longer term.

Balance between sales and research

Suthas keeps returning to the importance of maintaining focus. And this does not just apply in relation to the markets that the company wishes to enter. There is a constant challenge to hit the right balance between adding new value to the product and expending energy on sales activities. In this context the road to commercial success is paved with compromises. "If you focus too much on your sales activities, you will miss out on some of the exciting professional competency, which is the driving force as long as you stay in the world of pure research. On the other hand, it is certainly a fantastic experience to be involved in raising a small research project into an economically sustainable business. And when there is not enough time and money for everything, you will sometimes have to make some compromises", says Suthas. The transition from research to business involves a fundamental shift in the way in which you define your product. A prototype in a research project must of course satisfy various requirements and expectations, but it is a completely different story when you enter into a commercial market, says Suthas, "You very definitely notice that you are creating expectations with the customers that the product always works."

Expansion not possible

Suthas has had some thoughts about what could have made the transition to the commercial world less painful. "We have had some sound sparring from various quarters to the overall business strategy plan. However, we could have used more concrete advice as to which tools could be useful in day-to-day operation, for example for financial management as well as support and error correction. It would have been ideal to have a dedicated person as an adviser who had practical experience in these areas, he believes. He adds, however, that there are many experiences that you need to go through in order to be able to handle the competition in the longer term. There are currently five staff members at the InfoGallery who take care of everything, but Suthas does not rule out that this situation may change at some point. "If it proves that it would benefit the product and the business to bring people in from outside, for example for the more commercial areas, I would be completely open to this. I have always adapted to the needs of the product and I am sure that I in this situation could easily find a role where I could add value to the product and therefore also to the business. And this is what it is ultimately about", he says.

www.infogalleri.net

The Interactive HOSPITAL

- from research project to company

BY STIG ANDERSEN

PHOTO: INTERACTIVESPACES.NET

Researchers from the Department of Computer Science have been involved in the development of a solution for communication and overview in hospitals. The transition from research to business has travelled across a professional Board, a professional management team and an external investor.

It all started with the research project The Interactive Hospital, which ran from 2003 to 2006 in collaboration between Horsens Hospital, Center for Pervasive Healthcare at Aarhus University and the company Medical Insight. The project was such a great success that Horsens Hospital wanted to retain the system after the end of the project period. Today the interactive screens are in operation at 35 locations around the hospital, and part of the overview and communication that is necessary for the staff to organise the patients' journey through the various departments of the hospital as smoothly and efficiently as possible. Thomas Riisgaard Hansen wrote his PhD in conjunction with the research project, and is currently a post-doctorate at the Department of Computer Science and Director of Research in the company Cetrea. Cetrea is responsible for the development and selling of the solution that was initially developed for Horsens Hospital. Thomas Riisgaard Hansen says, "There were five of us from the original research project who continued in the new company including my supervisor Jakob Bardram. One of the first decisions was to decide whether we would let the company grow slowly, or whether we should take the major step and focus on a professional Board, external investors and a professional management team. We decided that it was a case of all or nothing.

Untrained in the world of business makers

According to Thomas Riisgaard Hansen this was a very good decision. The members of the Board were indispensable as sparring partners during the start up of the company. "Being technical people we are of course not trained "business makers" and for example we were not equipped to deal with the whole process of finding the right investors. We spoke with many potential investors until we found the right one, who was really interested in injecting capital into the company in order for it to flourish. Here, it was good to have the Board's experience to draw from, as it is immensely important to find the right investor", says Thomas Riisgaard Hansen. Other useful experiences were also gained during this phase, which consisted of selling the idea and product to an external investor. "At this early stage we learned that we needed to sell the whole product and not just the technology. If you want to appear serious in front of a potential investor, you also need to have an offer with regards to support, leads and everything else associated with the product itself", he says.

All dressed up

Backed by venture capital from FirmaInvest A/S in Århus, the company C3A, later to become Cetrea, was able to develop

the product further and build up an organisation. With the former Healthcare Industry Leader for IBM in Northern and Eastern Europe Hans Erik Henriksen in the director's chair, it was possible to build up a sales organisation among other things. And for Thomas Riisgaard Hansen, with his background in the world of research and technology, a number of new recognitions were on their way. "Of course we knew that it was important to sell some systems. But as a technical specialist you probably have an innate urge to appoint one more programmer in order to rectify bugs, or to further develop the product. And once again the Board pointed out that we might risk ending up with a perfect product that only a few people knew about. It is within healthcare seldom the feature list that sells the product. Particularly with regards to IT for the health sector there are a so many other facts that are important, before you can seal a contract. Here you need to involve people with experience in handling complicated sales processes", he says.

Back in the saddle?

There were also major challenges on the technical front, since the prototype from the research project was to be converted into a product. Actually all the code from the prototypes was discarded, and the solution was implemented from scratch. This was necessary in order to create an architecture that, among many other things, gave better opportunities for scaling and supporting the system.

In the last two and a half years Thomas Riisgaard Hansen and the other founders of Cetrea have spent a lot of time on the project. Much of this time has come from their spare time. The payment of the permanent staff in the company has first priority, so the hourly rate paid to the others involved in the enterprise cannot in any way meet the market level, according to Thomas Riisgaard Hansen. However, people are motivated by completely different factors. "It is immensely exciting to be able to create something that will actually be used, and to be involved in the whole decision-making process associated with the development of the product. We are not just a company where some of us dictate what is to be done, or not to be done. And even though there need to be a line in, I can always spend a Sunday coding something that I think should be added to the system", says Thomas Riisgaard Hansen.

> "In a company like ours the major challenge is the ability to deal with ups and downs, and to have belief in that the sales will come"

The Golden Scalpel

The interactive hospital in Horsens is shown a lot of interest, both from possible leads in Denmark, and from hospitals and research environments overseas working in related areas. The media coverage has also been very good, not least when on 4 September 2008 the Interactive Hospital was awarded the initiative prize the Golden Scalpel by the magazine Dagens Medicin. However a lot of interest is one thing, signatures on a contract are a different matter. "Sometimes it is just too exciting. One day the shop is full of customers, the other day it is as if everybody has agreed to go home. In a company like ours the major challenge is the ability to deal with ups and downs, and to have belief in that the sales will come. Fortunately, we now have people who are responsible for the whole process, and with the interest that is being shown in our product, it would probably pay off to roll it out in other hospitals", says Thomas Riisgaard Hansen.

www.cetrea.dk

Cetrea is responsible for the development and selling of the solution that was initially developed for Horsens Hospital.

The electronic school bag eBag was developed in a research project. Now the start-up company eBagSolutions is selling the solution to the Danish schools".

Put the electronic school bag in your pocket

<< A student opening his eBag on the smart board

< When the students' Bluetooth mobile phones are detected by a device that runs the eBag service, they are automatically logged in and their electronic school bags pop up.

BY STIG ANDERSEN

PHOTO: INTERACTIVESPACES.NET

By means of the electronic school bag, eBag, teachers and students have instant access to their materials. The solution implements many of the visions of pervasive computing. The vision of "pervasive computing", or as it is often termed "ubiquitous computing', was first formulated in 1988 by Mark Weiser, who at the time worked in the Computer Science Lab at Xerox PARC. According to Weiser, computing will gradually become embedded and therefore ubiquitous in our physical environment. The technology will be available - not because a user logs into a computer - but because computing devices sense the user is in the context in which activities take place and provide relevant services. According to Kaj Grønbæk, Head of Center for Interactive Spaces, the electronic school bag, eBag, largely meets Weiser's vision. "The eBag is a very good example of what one could call classic pervasive computing. With a Bluetooth enabled mobile phone in your pocket, you are automatically logged onto the eBag system when you are in the vicinity of an interactive SmartBoard or a PC with a Bluetooth dongle. The user's eBag folder becomes immediately available and you can start creating, editing and sharing the objects contained in your folder", he says. And when you leave the SmartBoard, you are automatically

logged out and the eBag disappears from the panel. Traditional content management systems also allow user-specific folders to be created and files to be placed in various group folders. However, with eBag the tedious layer of administrative procedures has been eliminated. "During the project we saw how cumbersome it was for both teachers and students to use many different computers including their portable computers to log in and navigate their way through the folder structures of a traditional shared file system. It took a very long time to log into and navigate to the correct folder. And it was very difficult to create flexible collaborate surroundings. In the eBag system you only extract folders from the users who work together between each other and in this way the objects are shared. When ad hoc groups created in this way are subsequently dismissed, the users still have access the shared group objects via their own folders", explains Kaj Grønbæk. However, the principle of seamless login and logout in the eBag implements the vision of the necessary tools being immediately available for users in the physical context in which a specific activity takes place. Instead of paper, post-its and pencils being on the desk in the classroom or meeting room, "pads, tabs and boards" will be available, as Marc Weiser put it.

And the point is therefore that users do not need to bring along notes and other materials in order to use the eBag at another location. This will be stored on so-called WebDAV severs, which support collaboration and where the necessary infrastructure exists, to be immediately available. The development of eBag has taken place within the framework of the iSchool project, where a number of companies and teachers and students from three schools in Århus have participated. The first prototypes were evaluated for a few weeks at Vestergaard School, this event was covered by Danish TV2 News, among others. Due to this coverage, the software house KMD became aware of the product and subsequently licensed the concept from Aarhus University. KMD prepared it for production and conducted the pilot test in six months in six schools before selling it to the start-up company eBagSolutions. The eBag solution has since been further consolidated with different administrative routines and is today in operation in four schools. According to Kaj Grønbæk there are major perspectives in the eBag solution in all contexts where people move around and have a need for easy access to relevant information, wherever they may be.

> "The eBag is a very good example of what one could call classic pervasive computing"

"Seamless login and logout, as we have used in the eBag solution, is perfectly suited to the work activities of a more nomadic nature. Hospitals are a good example of a work place where people are mobile and at the same time need to access digital information via different terminals without troublesome login procedures. Today, far too much time is spent logging in and out and navigating your way to the relevant information", says Kaj Grønbæk.

www.myebag.dk

The eBag stand at Education Forum 2006 in Odense. KMD had licensed the concept and used all of its exhibition space to advertise the product.

The Alexandra Institute brings together researchers and industry

WITH A COMPUTER SCIENCE PROFESSOR IN FRONT THE TEN YEAR OLD ALEXANDRA INSTITUTE HAS GROWN INTO A LARGE FIRM BY MATCHMAKING RESEARCHERS AND INDUSTRY.

BY ARNE VOLLERTSEN

When Professor Ole Lehrmann Madsen agreed to become director of the newly founded Alexandra Institute in 1999, he was promised that the position would not take up more than a few hours a week. The Alexandra Institute now employs over 75 staff members, has a branch in Copenhagen and a turnover on the right side of 40 million DKK. "We started the Alexandra Institute as a neutral forum where companies, researchers and public authorities could meet and develop collaborative projects of benefit to all parties. It has to be said that this vision has been realised beyond all expectations", says Ole Lehrmann Madsen, who has worked as fulltime Director of the Alexandra Institute since 2003. And he does not regret having assigned lower priority to his research in favour of his position as a bridge builder.

> "We started the Alexandra Institute as a neutral forum, where companies, researchers and public authorities could meet and develop collaboration projects that would benefit all parties. It must be said that this vision has been realised beyond all expectations"

Speeding up the collaboration

One of the instigators was the nationwide Centre for IT Research (CIT) along with a group of university people, business managers and representatives of the municipality and county who believed that public and private-sector collaboration in IT in Aarhus should be speeded up. With a strong IT business community and a strong research environment there was great potential for collaboration. This potential would be exploited by the Alexandra Institute and it would act as a bridge builder and neutral collaborative forum - a place where ideas and projects could be developed, which would be interesting both in terms of research and commercial value. "And we have succeeded in realising this vision", says Ole Lehrmann, who explains that the Alexandra Institute is now in the process of evolving into a private, application-orientated research institute, similar to the German Fraunhofer Institute and the American Stanford Research Institute, (SRI).

"Originally the Alexandra Institute worked primarily in matchmaking, networks and dissemination of information and as an instigator and administrator of projects. The actual projects were conducted by university researchers in collaboration with companies. "We have now entered into a new phase, in which we take an active part in the projects ourselves. We appoint researchers and developers who implement the projects in collaboration with university researchers and companies. This allows us to increase our project volume, since the university cannot provide the requisite number of researchers by itself.

Pervasive positioning

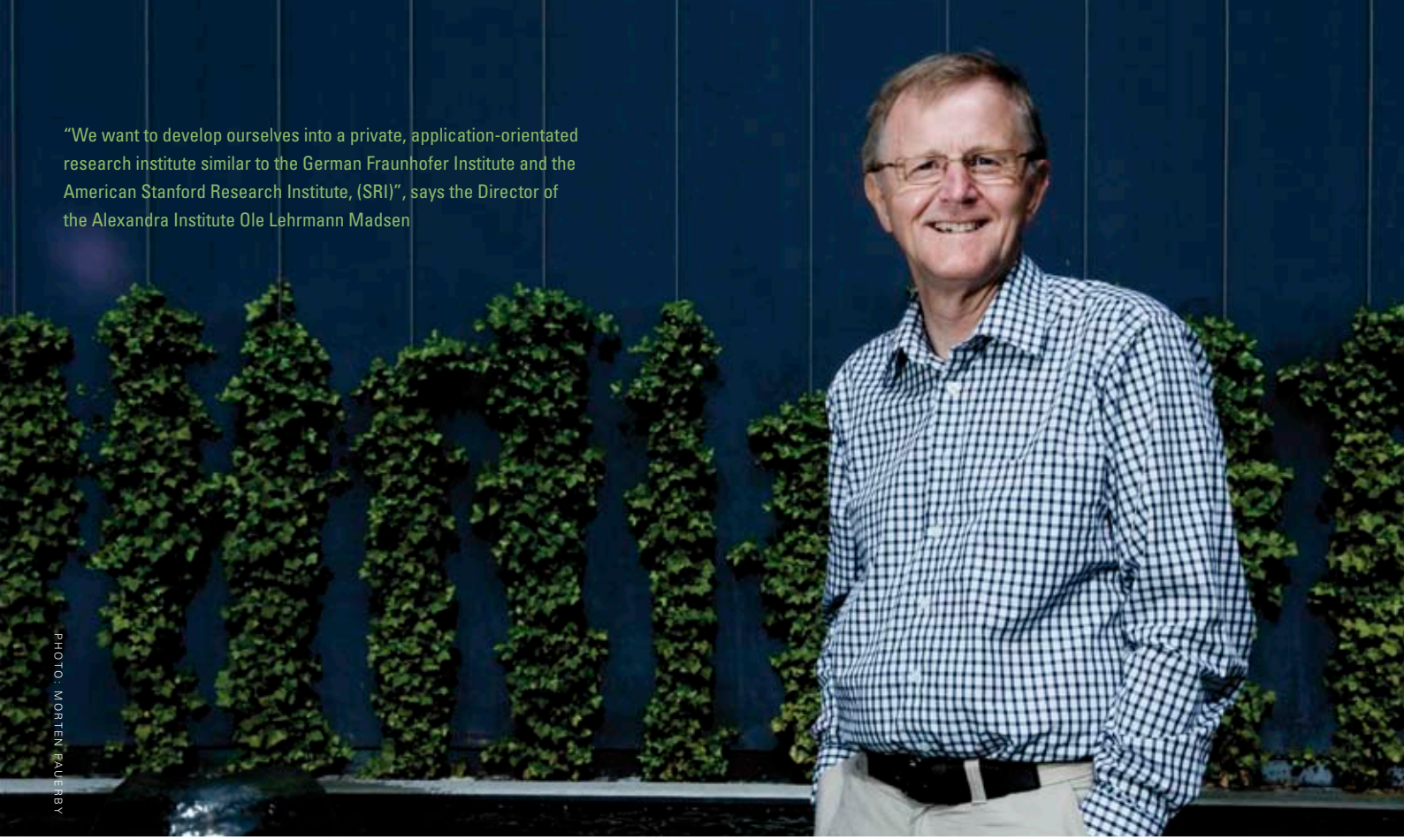
The focus area Pervasive Positioning develops competencies, tools, software and services that companies can use for new innovative positioning and localisation products. The focus area concentrates especially on knowledge build-up and commercial utilisation of Galileo, the European counterpart to the American GPS system. When Galileo is fully developed in 2013, the system will provide both greater accuracy than GPS (down to decimetres) and the possibility of indoor localisation.

New Ways of Working

The focus area New Ways of Working advises public and private organisations on adaptation and change processes that aim to create coherence between organisational structure, the concept of work, technology and physical office layouts.

The central themes are:

- How the perception of work can support or oppose collaboration and knowledge sharing



"We want to develop ourselves into a private, application-orientated research institute similar to the German Fraunhofer Institute and the American Stanford Research Institute, (SRI)", says the Director of the Alexandra Institute Ole Lehrmann Madsen

PHOTO: MORTEN FAUERBY

- Balance between professional/private life and borderless work
- How the layout of the workplace can support or oppose collaboration and knowledge sharing
- How IT solutions can support knowledge sharing and flexibility

Pervasive healthcare

Pervasive Healthcare pushes IT further into all aspects of the health service, both in the primary and the secondary sector. The primary focus areas of Pervasive Healthcare are:

- The hospital of the future: research into the application and development of pervasive computing technologies for use in larger hospitals, and development of technologies that link hospitals, the primary sector, e.g. own doctor or home care service, and the individual's own home.
- Home care: the use of pervasive computing technology to support self-treatment and care of individual patients and any relatives.
- Emergency medicine and accidents: IT support for paramedics and other personnel in the event of an accident.

Software Infrastructure

The focus area Software Infrastructure develops cross-disciplinary technology competencies primarily based on object technology. The foundation is the research environment of the Department of Computer Science.

The overall questions that software research focuses on are:

- What does new software infrastructure require when IT becomes ubiquitous?
- How do we develop and maintain software for pervasive computing systems that consist of a large number of distributed units?
- How do we handle security, privacy and safety-critical systems?

Business Understanding for Pervasive Computing

Business Understanding for Pervasive Computing is a relatively new focus area, which was established in November 2007. Business Understanding focuses on knowledge that can anchor technological innovation and ensure the optimum framework for a successful innovation process, e.g. innovation management, business modelling and impact measurement.

Advanced Visualisation and Interaction

The focus area Advanced Visualisation and Interaction works with visualisation in general, both through 3D stereo displays and through the utilisation of new technology for alternative media surfaces. Examples are interactive building facades and shop windows and newly-created combinations of digital and physical materials.

The focus area is also involved in visualisation within areas such as communication, dissemination of research, learning, branding and marketing, with special focus on the experience-orientated area and user-driven innovation.

Interactive Spaces

The focus area Interactive Spaces brings together architects, engineers and IT researchers to create new concepts for future IT-enriched surroundings. Interactive Spaces works with a broad spectrum of technologies, e.g. sensors and display technologies that can make IT functionality available in new ways in our working, private and educational surroundings. It is pivotal for the working methods of the focus area that the integration of IT into the surroundings takes place on the users' terms.

IT Security

The focus area IT Security brings together industry and research to discuss security issues in pervasive computing. On the commercial side, a number of software houses and specialist companies within security are involved in the collaboration. On the research side, the Alexandra Institute collaborates with the cryptology group at the Department of Computer Science.

www.alexandra.dk

Qualified research and qualified staff

BY MARIA ØSTER

PHOTO: B&O

Collaborations with research institutions such as the Department of Computer Science are of vital importance to Bang & Olufsen, as they enable us to gain an insight into the newest research.

Director of Innovation at Bang & Olufsen, Peter Petersen says that they are interested in several different dimensions of the research, "In a project such as Mobile Home Center, for example, we are interested in obtaining some fairly tangible results from the collaboration. What is involved here is product-oriented research, where our interest is quite tangible, he says.

However, the company is also interested in collaborations of a more recognizable nature, where a specific area is analysed in order to chart a more general problem area.

Director of Innovation at Bang & Olufsen, Peter Petersen, is convinced that through the collaboration with the Department of Computer Science, he will be able to upgrade the knowledge of his own specialists.

We must find the right balance

There must be a good balance between short-term, application-driven research and long-term research, which creates new general knowledge. This balance has not yet been found, believes Head of the Department of Computer Science, Kurt Jensen.

"Over the last 10-12 years the Department of Computer Science has experienced an enormous increase in the number of externally-financed research projects", he says.

"It is projects receiving funding from the Danish National Advanced Technology Foundation, the Danish Council for Strategic Research and other sponsors who allocate competitive public funds. Previously the vast majority of research money came in through the university's "front door", so to say and the university could then allocate these funds itself. This is no longer the case.

The competitive funds typically focus on short-term, application-driven research. There is nothing wrong with this in itself", believes Kurt Jensen,

"This is actually extremely healthy and at the Department of Computer Science

Bang & Olufsen is one of many companies, who over the years have taken an active part in research collaborations with the Department of Computer Science. To keep close relations to the professional environment the company has placed one of its software development departments at Katrinebjerg.

"As a company we are happy to focus on both parts. We have a major interest in charting specific focus areas, but naturally we are also interested in solutions that nobody before us has discovered", explains Peter Petersen.

Apart from the research-related interest Bang & Olufsen is also greatly interested in educating its own personnel through the collaboration. The company has employed a number of specialists who attend to research-related activities in their daily work.

"In collaboration with the professional researchers from the educational institutions we will be able to upgrade the knowledge of our own specialists in a research-related direction".

On the lookout for core competences

Bang & Olufsen has a software development department at the Incuba Science Park at Katrinebjerg. Around 20 personnel, primarily computer scientists and other software developers, conduct their daily activities here.

"As our employees actively participate in the collaborative projects, it is important for us to be physically represented in the area", explains Peter Petersen and continues, "The software environment in Århus is certainly attractive, and therefore it is also attractive for us as a company to be part of this environment. Of course, our presence is also a result of us wishing to attract personnel who are qualified within the software area to the company.

Peter Petersen explains that the company is principally looking for a combination of the profound computer science knowledge and the knowledge of user interfaces in its collaboration with the Department of Computer Science.

"You could say that we are interested in both the soft and the hard competencies.

Collaboration on a Readership

Bang & Olufsen has entered an agreement with Aarhus University, which means that the company will partly finance an Associate Professor post in the Department of Computer Science within the area of "software architecture for distributed embedded systems".

"We have a general policy of preferring to have research collaboration within our core competence areas, and financing Associate Professor posts in collaboration with universities that possess the competences we are looking for gives us an insight into valuable research", explains Peter Petersen.

The collaboration of the Associate Professor post will enable both staff and students to utilize Bang & Olufsen's facilities.

The future with the Department of Computer Science

Bang & Olufsen has collaborated with the Department of Computer Science for about six years and the Director of Innovation does not doubt that this collaboration will continue:

"Up to now our experiences have been good. Therefore, we will continue our good and deep collaboration with the Department of Computer Science. There is no doubt about this.

Read more about the role of the Department of Computer Science in the Bang & Olufsen project on page 30

we are very satisfied by the fact that we are the best IT department in Denmark to attract these funds. However, I do believe that the focus on application-oriented and industrial areas is out of control. It has become very difficult to secure funds for more long-term research", he adds.

Prioritisation of long-term research

Almost two thirds of the work of the Department is financed by external funds. Some of these funds go to basic research, e.g. in Center for Massive Data Algorithmics, MADALGO, financed by the Danish National Research Foundation. However, this does not change the fact that an unfortunate and untenable imbalance has arisen between short and long-term research", says Kurt Jensen and continues,

"I believe that there must now be a prioritization of basic funds for research with a long-term perspective. And I agree with the political parties that are working towards a significant increase of the basic funding awarded to universities.

The Department of Computer Science has a high international standing in research and this is one of the reasons why we are able to attract so much external research funding. However, at the same time we need to be able to long-term invest in developing new competences.

We must have greater opportunities to research subjects that may not have a tangible commercial perspective for ten or twenty years. Otherwise we will quickly lose our international level. If we do not secure the long-term development, we will not be able to maintain the high level of short-term, application-driven projects. The long-term is the pre-requisite for the short-term and we currently lack resources to create the correct balance between the two", says Kurt Jensen.

From DNA to toolboxes to smoke and then to linguistics. Broadly speaking, all conceivable corners of computer science will be explored within the nine research groupsat the Department of Computer Science.

THE 9 research groups

RESEA

Some of the research groups are units that work intimately and specifically withina single discipline, while other groups work both within and outside of their own disciplines, and collaborate with other research groups of the department, or with academic environments outside of the Department of Computer Science.

Read about the activities of each of the nine research groups > > >

RCHES AT THE DEPARTMENT OF COMPUTER SCIENCE

 # 1 Algorithms & Data Structures

 # 2 BioInformatics

 # 3 Object-Oriented Software Systems

 # 4 Computational Complexity Theory

 # 5 Cryptography & Security

 # 6 Human Computer Interaction

 # 7 Modelling & Validation of Distributed Systems

 # 8 Programming Languages & Formal Models

 # 9 Computer Graphics & Scientific Computing

1

ALGORITHMS & DATA STRUCTURES

THE RESEARCH GROUP

PHOTO: JESPER VOLDGAARD

FULL ***SPEED*** BLOCKS

Algorithm's leading speed hogs can be found on the first floor of the Turing Building and go by the names of Lars Arge and Gerth Stølting Brodal.

BY PETER GAMMELBY

Lars Arge and Gerth Stølting Brodal use I/O-efficient algorithms to make computers solve problems at unprecedented speeds. And quite unashamedly they term themselves world champions in this discipline.

Together they form the research group Algorithms & Data Structures, which is closely associated with Peter Bro Miltersen and Gudmund Skovbjerg Frandsen's research group on complexity theory and game theory.

What makes Professor Lars Arge and Assoc. Prof. Gerth Stølting Brodal leaders within their field is their development and use of special mathematical machine models that accurately models that modern machines have several layers of memory, which become slower the further away they are from the processor.

Limited memory

Many algorithms are based on the RAM model of computation (where RAM stands for Random Access Machine), which is somewhat old-fashioned but still very widespread.

One main disadvantage of the RAM model is that it is based on an infinitely large main memory, where data in any memory location can be accessed in the same time.

However, real computers are typically equipped with four layers of memory: L1 cache, L2 cache, the main memory (RAM, as in Random Access Memory) and finally one or more hard disks.

The cache and the RAM is typically a million times faster than the hard disk. As the cache is small and the RAM maybe not much larger, the RAM model is often completely unrealistic; at least when dealing with massive datasets or when using a small machine.

Smart data layout

"We are really good at designing algorithms that take the memory hierarchy into account. Our I/O (Input/Output) algorithms attempt to minimise the number of reads and writes on the hard disk. We do this by laying out data on the disk in a smart way, such that the machine is forced to only retrieve blocks of data from the disk where all or most of the data is used", explains Lars Arge. The point is that usually the machine does not only retrieve the specific data that is requested, but rather blocks of data of 8, 16, 32 or 64 kilo bytes at a time. Therefore one will typically get some data that is not needed, but just taking up space, when accessing the data one needs.

Effective on all platforms

A new hot area for the group's research is algorithms that minimise the number of reads and writes at all layers of the memory hierarchy. The goal is to design algorithms that are efficient on all platforms – from a super computer to a cell phone.

"These types of algorithms are called "cache oblivious", but so far the results are mostly theoretical. Experiments will show whether the theory can be used in practice", says Gerth Stølting Brodal.

The work on developing new mathematical models to replace the Random Access Machine continues. New types of memory, such as flash memory, that requires new models and algorithms are continually appearing.

> "The goal is to design algorithms that are efficient on all platforms – from a super computer to a cell phone"

Finally, mathematical theories and models are not everything. The duo is also working extensively on algorithm engineering, that is, on efficient algorithm implementations and experimentation with real data. For example, Gerth Stølting Brodal is collaborating with the Bioinformatics Centre on algorithms for genome analysis, while Lars Arge is working with biologists on practical algorithms for terrain processing and biodiversity modelling problems.

faults no obstacle

Regardless of whether you are looking for Christensen in the telephone book, or searching Google's data directory, a fault can make your search futile. Using fault tolerant algorithms, Lars Arge and Gert Stølting Brodal are removing the obstacle faults represents to algorithms.

BY PETER GAMMELBY

Speed is not everything. What use is it to have a super smart algorithm to help a computer solve problems at lightning speed, if a sudden fault in the memory causes the computer to crash?

This is what Lars Arge and Gerth Stølting Brodal are attempting to prevent by developing so-called "fault tolerant algorithms". These are algorithms that continue to work even in the presence of faults.

A fault in the memory will result in the processor not receiving the correct values back from the RAM. Such a sudden fault can be caused by background radiation, where a charged particle passes through a RAM cell. The particle can leave a trace of electric charge by colliding with the atoms in the microchip, and this charge can be of sufficient magnitude to change a bit from 0 to 1 or visa versa. Such an event is termed "Single Event Upset".

Faults ruin searches

With a normal family PC the risk of faults is negliable, as the PC is only in use for shorter periods at a time, and the memory is therefore fairly stable. However, if you have millions of machines that are constantly running, such as Google, the risk of faults in the memory is much greater. The risk also increases if inexpensive memories are used.

"If a fault occurs in the memory, this can destroy a binary search, for example. Using fault tolerant binary search you not only make a lookup in the middle of the data; you also perform one or more redundant look-ups at the same time, in order to verify that what you had previously found is correct", explains Lars Arge.

Binary search looks for an element in a group of sorted data by first inspecting the middle element to see whether it is greater or smaller than the element being searched for. After this the middle element in the sub-interval in which the element is located is inspected, and so on.

> "If you have millions of machines that are constantly running, such as Google, the risk of faults in the memory is much greater"

Christensen is missing

This is equivalent to looking for Christensen in a telephone book. First you look in the middle of the book at, say, Jensen. Already now you know that Christensen is located in the first half of the phone book. So you look in the middle of the first half of the book at, say, Eriksen, and know that Christensen is in the first quarter of the book. Then you halve again and find Bruun, knowing Christensen must be in the following eighth of the book. You continue doing this until Christensen has been found.

But if there is a fault in the telephone book, and you find an Andersen in the middle of the book, the algorithm will look for Christensen in the second half of the book, even though he is in the first half. You therefore never find Christensen, who has to sit and wait by the telephone in vain.

If the algorithm is fault tolerant, you do not restrict yourself to only looking in the middle of the phone book. You look in several places at the same time in order to ensure that the first find is correct. If it is not correct, the algorithm will find out and still find Christensen.

"We would like an algorithm to be able to handle delta faults, that is, we want to guarantee that the algorithm will work even if delta faults occurs during the algorithm. For usual binary search, delta is zero. In theory, we know how to handle delta errors in a binary search. We are now investigating if it works sufficiently well in practice", says Lars Arge.

See on page 24-25 how a game theory researcher won the unofficial World Champion of Robot Poker

1 ALGORITHMS & DATA STRUCTURES

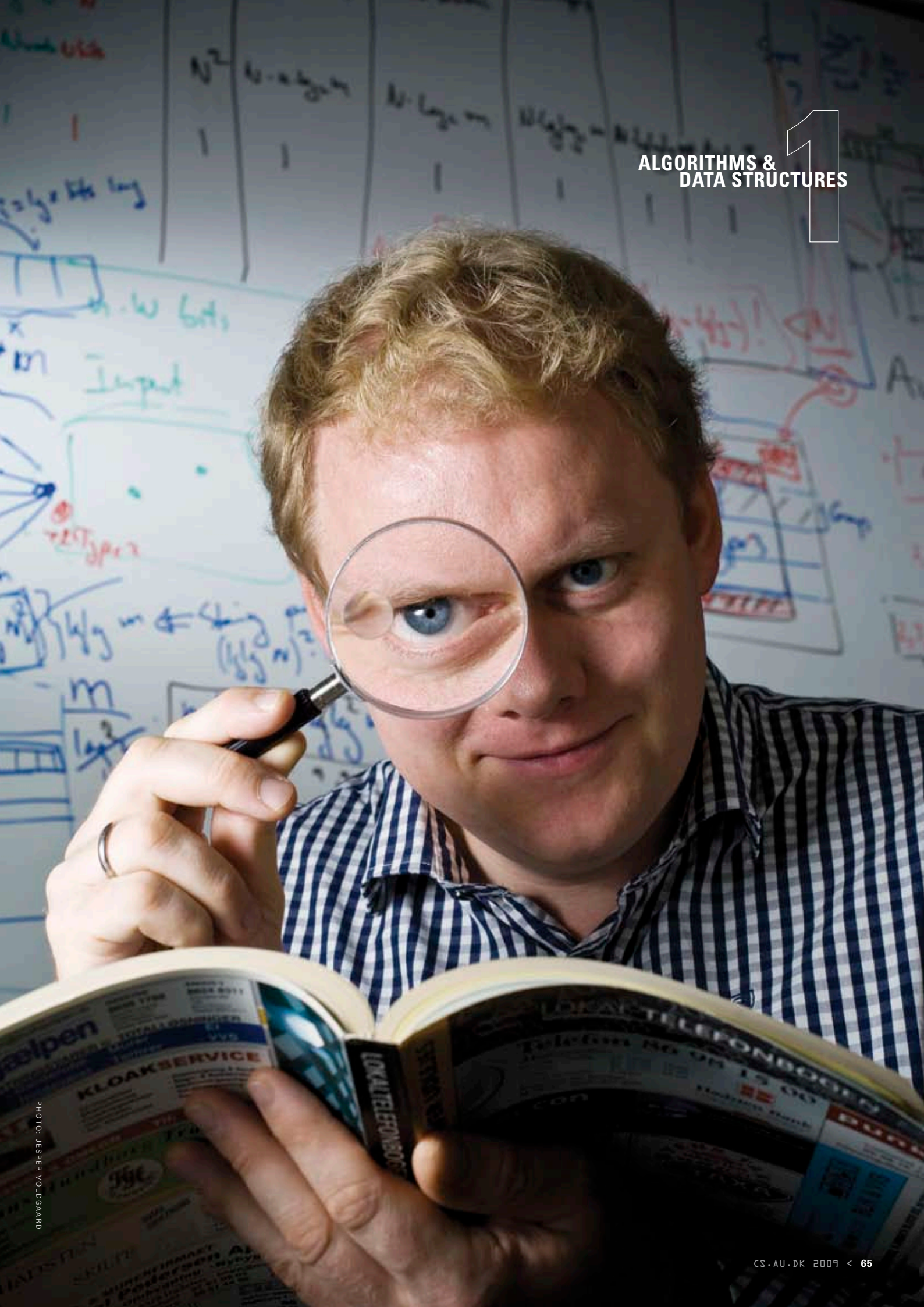


PHOTO: JESPER VOLDGAARD

2

THE RESEARCH GROUP

BIOINFORMATICS

PHOTO: JESPER VOLDGAARD

WHEN SIMPLE ALGORITHMS AND RAW COMPUTER POWER MEET GENETICS

Today the human genome has been fully sequenced. And the enormous quantity of data that is contained within the DNA molecules makes it possible to analyse relationships between species. Researchers at the Bioinformatics Centre (BiRC) are developing methods to deal with the large quantities of data.

BY STIG ANDERSEN

A broad perspective approach and the correct methods are required in order to obtain reliable results from the data contained in the human genome. Asger Hobolth, Assoc. Prof. at the Department of Mathematical Sciences at Aarhus University and affiliated to BiRC, explains,

"The methods that we have developed are able to scan through the whole genome and in this way give very reliable indications of the relationship between e.g. the humans, the chimpanzee, the gorilla and the orangutan. By comparing the DNA from the different species we can identify a number of patterns that can be used in our statistical analyses".

output is a number of very large tables that can be used to define the probability of a relationship between two species", explains Assoc. Prof. at BiRC, Thomas Mailund.

It can take up to 100 CPU days if the algorithm is executed on BiRC's own machines. If this is to be made more efficient, we borrow computer power from other research institutes and the CPU time can be reduced to "only" a week.

This is why people are different

The original aim of the method was to establish a date for speciation, for example when humans and chimpanzees separated into independent species from their common ancestor. Other methods are available, but the method developed at BiRC can be used to substantiate the conclusions that have been reached using a different method. The most sensational result that the method has thrown up to now is to make it highly probable that the human species is only 4-5 million years old and not 5-7 million as many people have until now assumed.

> "IT CAN TAKE UP TO 100 CPU DAYS IF THE ALGORITHM IS EXECUTED ON BIRC'S OWN MACHINES. IF THIS IS TO BE MADE MORE EFFICIENT, WE BORROW COMPUTER POWER FROM OTHER RESEARCH INSTITUTES AND THE CPU TIME CAN BE REDUCED TO "ONLY" A WEEK"

However, dealing with the large quantities of data is not an easy task:

"The algorithm of the method is very simple, otherwise we wouldn't be able to analyse this amount of data. Genetics and statistics are the more complicated areas. The input to the algorithm is a table with 36 states and 2 billion positions and the

Mikkel Schierup, biologist at BiRC, explains,

"Using DNA sequencing, we are now able to tell why people are different. And we are therefore able to inform about the risk of developing different diseases. Similarly, we can look at the DNA information of related species and in the historical perspective say something about the original species' "risk" of developing into a human. And this actually puts us in a position to say something about how natural selection functioned around the time of speciation."

When we have established the probability of a relationship between species the perspectives are broad, according to Mikkel Schierup. As an example, he mentions a theory that researchers at the Broad Institute, a collaboration between MIT and Harvard, have put forward:

"Researchers at the Broad Institute believe that during the phase in which the human and chimpanzee species separated there occurred a certain degree of "hybridisation" where the two future species continued to reproduce. Eventually as additional data becomes available, we will be able to use our method to verify this claim.

PHOTO: JESPER VOLDGAARD

INTERDISCIPLINARY COLLABORATION MAPS HUMAN GENETICS

The Bioinformatics Centre (BiRC) is placed in the most distant corner of the University Park. It is here methods to translate the ever increasing volumes of biological data into knowledge of the origins of mankind and genetic make-up are being developed.

BY STIG ANDERSEN

Every once in a while news from the scientific world finds its way into newspaper columns. This happened in January 2007 where methods, developed by a research team based at the Bioinformatics Centre at Aarhus University, were used to demonstrate that humans became an independent species 4-5 million years ago and not 5-7 million years ago as previously supposed. At a stroke it was made probable that a series of fossil finds estimated to be approximately 6 millions years old did not stem from a human but rather from a human-chimpanzee forefather.

Results of this calibre emanate from the interdisciplinary collaboration, which is the core of the work at the centre and which brings together people from the disciplines of computer science, statistics and biology. Christian Nørgaard Storm Pedersen, Assoc. Prof. at the Department of Computer Science at Aarhus University and leader of BiRC since June 2005 states,

"There are about 40 of us at the centre and we are involved in a large number of projects. If it makes any sense, you may say that around two thirds of our work is pure basic research and a third is more usage-orientated.

Important knowledge

BiRC's main activities are focused on the development of new methods within the area of association mapping (the mapping of DNA, for example, in order to evaluate the probability of developing diseases), genome analysis (e.g., the temporal establishment of the emergence of the species) and structural bioinformatics (e.g. studies of the dynamics of proteins). The core of the work is a fruitful crossing of large volumes of biological data with the correct algorithmic and statistical methods. Thomas Mailund, Assoc. Research Prof. at BiRC states:

> "IF IT MAKES ANY SENSE, YOU MAY SAY THAT AROUND TWO THIRDS OF OUR WORK IS PURE BASIC RESEARCH AND A THIRD IS MORE USAGE-ORIENTATED"

"In recent years the methods for DNA sequencing have become so good that we have had enormous volumes of data about the human genome at our disposal. We have therefore developed methods making it possible for us to perform a through scan of human DNA. We thereby gain important knowledge on e.g. the probability of a person developing a specific disease.

The methods and tools that are being developed by BiRC will be presented on the website www.birc.au.dk and can be used by the centres and institutes that conduct the actual analyses of biological data.

Turned on students

BiRC is also involved in a number of teaching activities where the direct use of the algorithms is a clear motivational factor.

"We offer the students the opportunity not just to learn about some exciting algorithms but also to actually implement and experiment with them. And I believe this really turns them on", says Centre Leader Christian Nørgaard Storm Pedersen.

However, there are other aspects of bioinformatics that make this a fascinating discipline. Computer Scientist Søren Besenbacher, who has just finished his PhD thesis on association mapping is in no doubt:

"It is always exciting to be involved in an area where something actually happens. I believe that just now association mapping is extremely exciting, as it represent a scientific revolution. We have been successful in getting the first human DNA to sequence and we therefore know what a typical human looks like. Now we have to find out why there are differences between people, which of course there are. This is where great progress is being made. It is only in recent years that twice as many disease genes as were previously known have been discovered.

3

THE RESEARCH GROUP
OBJECT-ORIENTED SOFTWARE SYSTEMS

PHOTO: JESPER VOLDGAARD

A CORE IN KATRINEBJERG

Object-oriented programming easily fits in with pervasive computing and is one of Katrinebjerg's core competences. This is why the research group Object-Oriented Software Systems (OOSS) has a tradition for its members to be spread over a large number of experimental projects.

BY PETER GAMMELBY

When we deal with pervasive computing, Object-Oriented Programming (OOP) is essential since the technology is not dependent on hardware and operating systems. Components programmed with OOP (e.g., in Java or C++) can be directly transferred from a computer to small units that can therefore be located and used anywhere.

Since the early 1970s, the Department of Computer Science at Aarhus University has created a leading role for itself in the development of object-oriented software. This is partly due to the fact that shortly after its foundation the inventor of object-oriented programming, Kristen Nygaard from Norway, visited the department as Guest Professor.

He initiated a project that would develop a new programming language, Beta, which together with a number of other object-oriented technologies such as Simula and Smalltalk are the basis for Java, C++ and C#, among others.

Since then the department has turned out several internationally acclaimed researchers within this field. These include Bjarne Stroustrup, who is the man behind C++, and Lars Bak, who has had major influence on Java technology and who is also behind the V8 machine in Google's new browser, Chrome.

Some of the OOSS group's projects have developed into spin-off companies, for instance Beta was the basis for Mjølner Informatics, of which the leader of the group, Ole Lehrmann Madsen, is Chairman of the Board.

Practical and experimental

With the establishment of the competence centre ISIS Katrinebjerg in 2002 (which was granted DKK 44 million over four years to enhance research and development work between the business community and the IT knowledge environments of the Århus region) the research into object-oriented programming increased – not least in the practical and experimental area.

> "A SIGNIFICANT PART OF THE WORK RESEMBLES EXPERIMENTAL PHYSICS, SINCE WE BUILD THINGS OURSELVES AND EXPERIMENT WITH THEM"

Assoc. Prof. Klaus Marius Hansen from OOSS explains,

"OOSS' research currently focuses on three things: programming of pervasive computing systems, software architecture, and pervasive computing systems in teaching. A significant part of the work resembles experimental physics, since we build things ourselves and experiment with them. We have a tradition of focusing on building tools and applications of programming languages, rather than focusing on e.g. mathematical proofs. The objective is to find new methods of writing programs, rather than to prove characteristics of the languages. And ISIS has financed the majority of our projects.

As the focus is now mostly on the practical application, there are not many people left in the group from the theoretical research in programming languages, and one of our members recently transferred to the Programming Language group.

Scattered to the four winds

The members of the group spend as much time with other parties as they do with each other as they are involved in a large number of external projects with, among others, private companies such as B&O, Dansk Landbrugsrådgivning, Jyske Bank, Servodan, Systematic and Terma.

And also with other research institutes, centres and networks such as Center for Pervasive Computing, CISS – Centre for Embedded Software Systems at Aalborg Universitet, Center for Software Innovation in Sønderborg, the Ludwig-Maximilian University in Munich, the Fraunhofer Institute and the Alexandra Institute.

Amongst the previous collaborative projects are GoalRef (a ball that senses when a goal has been scored) and LIWAS (a traffic safety system that can turn vehicles into mobile weather stations using sensors and communication equipment). OOSS has also had its hand in the EU-financed project Palcom (which focused on the area of healthcare and was all about creating an infrastructure for pervasive computing and making the technology transparent for users).

At present the group is involved in another EU project, Hydra, which is about the creation of new middleware for embedded systems in networks.

Read about Kristian Ellebæk Kjær, who develops IT products for the farmers on page 9

On page 11 you can read about how Jeppe Brønsted developed an icy road sensor

3 OBJECT-ORIENTED SOFTWARE SYSTEMS

OOSS IS CURRENTLY CONDUCTING RESEARCH INTO LIMBO AND FLAMENCO. THIS SOUNDS MORE EXOTIC THAN IT ACTUALLY IS. IT IS ALL ABOUT THE GROUP'S CONTRIBUTION TO AN INTERNATIONAL CONSORTIUM THAT IS TO CREATE A COMMON PLATFORM FOR BILLIONS OF DIGITAL DEVICES.

PHOTO: JESPER VOLDGAARD

Hydra in the middle

BY PETER GAMMELBY

The amount of IT equipment that is able to communicate will increase from 0.24 to 1 billion in 2012. Both mobile and embedded devices, sensors and various kinds of digital gismos are produced in large quantities by different manufacturers, and are deployed and put into operation in an increasing number of different places, and many of these will have to be able to "talk" to each other.

In order to simplify the communication between these devices, an international consortium began creating new middleware for embedded systems in networks

> "Embedded systems are difficult to manage, so an architecture that supports self-management is important"

two years ago. We are talking about a four year project called Hydra.

Middleware is, as the name would imply, a layer of software that is placed between the operating system of devices and the various applications that run on them in order, among other things, to ensure reliable communication.

The applications often come from widely diverse suppliers and are based on different architectures and protocols and without middleware. A company could use a lot of its resources in integrating the applications with each other.

The vision of the Hydra project is to create the most widespread middleware for intelligent embedded systems in networks, which will make it possible for manufacturers to develop cost-effective and innovative applications for new and existing devices.

The project focuses on three areas of application: the health service, intelligent houses and agriculture.

Strictly Come Dancing

At OOSS work is being carried out on two angles for the Hydra project:

"The first one is based on the creation of web services for embedded systems, e.g. systems in a factory (such as in production machinery) or in the home (e.g. in a television or on hard disc recorders) so that they can be included in larger systems. The second is based on the development of self-managing systems, that is to say systems that can monitor themselves and react to faults. Embedded systems are difficult to manage, so an architecture that supports self-management is important", says Klaus Marius Hansen, who is the leader of the project at Aarhus University.

And there is something that could suggest that the research group are fond of dancing. At any rate they have chosen to create a Java-based web service compiler called "Limbo", and the tool for self-management has the similarly danceable name of "Flamenco". Limbo relates to the use of few resources (the dance is all about keeping the body as low as possible) and Flamenco was chosen as a name as we were still in the world of dance.

Flamenco monitors and makes decisions

"The Flamenco system will monitor the status of the units and make decisions on the basis of this. The software will therefore carry out both diagnoses and control. If a service fails, the service may have to be transferred to another unit. In addition to this, Flamenco could be used for planning; if you have quality targets for data communication and these cannot be fulfilled, Flamenco could, e.g., ensure that the data was stored on the disc and communicated later. The system is therefore to react to conditions that had not initially been envisaged so that deterministic algorithms do not need to be created for all possible conditions", explains Klaus Marius Hansen.

> "The software will carry out both diagnoses and control"

The diagnosis part has already been realised, the control part is in the process of being realised and the planning part is – well, in the planning phase.

"And we still have two years to complete it", he adds.

The other participants in the consortium are In-JeT ApS and Priway ApS from Denmark, T-Connect S.r.l. and Innova S.p.A. from Italy, Telefonica I+D SA from Spain, University of Reading from the UK, CNet Svenska AB, Fraunhofer-Institut für Angewandte Informationstechnik, Fraunhofer-Institut für Sichere Informationstechnologie, Universität Paderborn and Siemens AG, Siemens IT Solutions and Services from Germany as well as Technical University of Košice in Slovakia.

4

COMPUTATIONAL COMPLEXITY THEORY

THE RESEARCH GROUP

PHOTO: JESPER VOLDGAARD

Complexity Theory from the underground

In the basement of the Turing building a group of people are working on complexity theory. From a place just under the surface of the earth they tackle some of the most fundamental problems of theoretical computer science.

BY STIG ANDERSEN

I believe that if we were at an American university we would be called "the Theory Group", says Peter Bro Miltersen, Professor and leader of the Department of Computer Science's complexity theory group. Together with two post docs Maurice Jansen, Kristoffer Arnsfelt Hansen and an academic researcher Gudmund Frandsen, he works on creating a theoretical basis for evaluating which solution methods should be focused on. Peter Bro Miltersen states:

"Complexity theory is all about which types of algorithms are able to solve which problems. People believe that this is all very theoretical, but in reality it is incredibly practical. The most important thing is that the theory can be used to eliminate the types of algorithms that cannot be used. You are blind when attempting to navigate through a room of possible solution methods if you are not familiar with this theory.

A one million dollar question

To mark the entry into the new millennium in 2000, the Clay Mathematics Institute of Cambridge in Massachusetts, USA, set out seven mathematical problems, known as the Millennium Problems, and offered a prize of 1,000,000 USD for the correct solution to each of the problems.

One of the problems is quite simply expressed as P=NP? This expresses the fundamental problem with which complexity theory concerns itself. Peter Bro Miltersen explains,

"If P is equal to NP, this means that for each problem that could be solved by means of an exhaustive search, there is a much more effective method than this exhaustive search, namely a method that uses time that is not exponentially increasing with the size of the specific problem.

> "If the problem can be categorised as NP-hard, you should not waste more time using such a method, unless of course P is equal to NP and as I have already stated, we do not believe this to be the case"

Complexity Theory in practice

As anybody who has attempted to find a needle in a haystack will know, there are problems that appear to only be solvable through a thorough search. This is why the majority of researchers believe that P is not equal to NP. Certain concrete problems are termed as being "NP-hard". These problems could only be solved in sub-exponential time if this were possible for all problems in NP and here complexity theory can be used practically:

"If you know your complexity theory, it would not take long to evaluate whether a solution method, for example one based on linear programming, could be used at all. If the problem can be categorised as NP-hard, you should not waste more time using such a method, unless of course P is equal to NP and as I have already stated, we do not believe this to be the case", says Peter Bro Miltersen.

The fact that the problem is NP-hard does not mean that you need to give up. It just means that some other types of algorithms should be used that can bring you a sufficiently good solution.

From algebraicists to cryptologists

The complexity theory group works in close collaboration with other groups including the game theory group, with which it overlaps on a personal and thematic level. However, they also work together with a broad spectrum of people and disciplines from algebraicists to cryptologists.

The group is financed through a combination of faculty funds and funds from the Danish Natural Science Research Council and the Carlsberg Foundation.

Read more about their work on game theory on pages 24-25

With a starting point in the methods of classic computer science, Johan Kjeldgaard-Pedersen, Senior Consultant at PA Consulting Group, places practical problems into theoretical models. This results in specific suggested solutions.

PHOTO: JESPER VOLDGAARD

Complexity Theory solves real problems

BY STIG ANDERSEN

Johan Kjeldgaard-Pedersen is 32 years old, graduated as a computer scientist from Aarhus University in 2000 and is currently working as a senior consultant in the Decision Sciences unit at PA Consulting Group, which is a global consultancy company. He advises the likes of public authorities and companies involved in the shipping, energy and pharmaceutical sectors before they launch major strategic changes and initiatives. Perhaps not the most obvious place to find a computer scientist, but then again. Johan explains,

"Since I graduated from the Department of Computer Science at Aarhus University I have done everything I can to minimise my involvement in IT– especially requirement specifications, user tests and the like. On the other hand, I have been attracted to classic computer science and I quite simply find complexity theory beautiful. You become highly trained to think both abstractly and creatively, and there is a need for this when you have to assess complex problems in the business world".

> "I HAVE BEEN ATTRACTED TO CLASSIC COMPUTER SCIENCE AND I QUITE SIMPLY FIND COMPLEXITY THEORY BEAUTIFUL"

Commercial scientists

An example of what Johan and his colleagues at Decision Sciences are involved in could be a pharmaceuticals company that needs to find the most profitable strategy for the launch of a new product.

"The order of the countries in which the product is to be launched is extremely important and in actual fact the difference between a good and a bad launch sequence can mean a difference in profit of billions of DKK", explains Johan. There are many parameters at play and a theoretical approach is necessary in order to get to the crux of the problem and come up with a good solution".

"Of course you need to have a certain amount of data and some specific technical knowledge in order to be able to advise a pharmaceuticals company. However, we offer our clients something extra, namely the ability to work with their commercial problems at an abstract level and then return to the practical world with some specific solutions. So you could call us commercial scientists", says Johan.

> "WE WOULD NEVER DREAM OF TELLING A CLIENT THAT HE IS ACTUALLY WORKING ON A PROBLEM THAT IS "NP-HARD"

Scientific bull shit – no thanks!

However, the client is not involved in any of the underlying theoretical considerations:

"We would never dream of telling a client that he is actually working on a problem that is "NP-hard". The client is not interested in this type of scientific bull shit. He is looking for some solutions that will create value on the bottom line. However, in our work finding solutions, the complexity theory is useful for identifying what type of problem we are dealing with", he says.

The rest of Decision Sciences' toolbox contains mathematical modelling, operations analysis, game theory, simulation, graph theory and process analysis. Since the assignments almost always involve large quantities of data and calculations, we often use advanced software and sometimes also develop in-house applications.

"However, the problem of finding a good launch sequence is actually NP-hard, so we have developed a tool based on so-called "simulated annealing". This is a method for looking for good solutions to a problem that could otherwise in theory only be solved by a thorough search", concludes Johan.

5

THE RESEARCH GROUP

CRYPTOGRAPHY & SECURITY

PHOTO: JESPER VOLDGAARD

CRYPTOGRAPHY ENSURES THE USE OF VALUABLE DATA

When the researchers at Aarhus University develop systems that use and protect data simultaneously it breaks with the traditional cryptography.

BY BJARKE ROSENBECK

We come with a positive message from cryptography, which is otherwise known as 'the science of the paranoid", says Jesper Buus Nielsen, post doc and part of the research group 'Cryptography & Security' at the Department of Computer Science at Aarhus University.

The positive message is about the implementation of theoretical research that has been known since the mid-1980s. Today it is possible for computers to perform some very complex calculations.

Technology enables researchers to develop systems to perform secure multi-party calculations.

"Imagine that we have 100 parties and each of these parties possesses secret data. We want a conditional function that can extract a specific quantity of information out of the total data quantity The system presents a result without anybody being able to gain access to anything besides the result itself", says Jesper Buus Nielsen.

Saving an auditor

However, as Jesper Buus Nielsen points out, there are of course other methods of calculating a result from a distributed set of data.

"We could also send data to an auditor who assembles all data and computes the result. However, this would mean having a central person who has seen all data - and who do we trust enough, person or company, to safeguard it all? This person does not exist", explains Jesper Buus Nielsen.

There is groundbreaking research being carried out at the Department of Computer Science at Aarhus University. Professor Ivan Damgård has been part of this research area since the 1980s and today Århus, together with Zurich in Switzerland, is the standard bearer for a new method of viewing cryptology. It is no longer just about protecting data.

"A simple method of protecting data is by never using it. It's a simple matter if it's only a question of protecting data", says Jesper Buus Nielsen.

"What we would like to do is to use data and at the same time protect this data", says Jesper Buus Nielsen.

From sugar beets to the rest of the world

The research group is very satisfied with the results produced up to now. Until now the system has been developed to deal with an auction on the Danish sugar beet market. It was a success. An EU project has now been launched and in the future a programming language will be developed that is more accessible to programmers who are not specialists in cryptology.

In the future the researchers hope to be able to commercialise the auction project. Users could create an auction and have the opportunity to specify the content of a specific auction.

> "A SIMPLE METHOD OF PROTECTING DATA IS BY NEVER USING IT. IT'S A SIMPLE MATTER IF IT'S ONLY A QUESTION OF PROTECTING DATA"

Research into cryptology and security can often be a heavy academic and theoretical discipline. Nevertheless, the researchers maintain a focus on the cryptology that is useful in practice.

"In order to get the research underway we collaborate with the Alexandra Institute, and a large number of our PhD students are associated with tangible, usage-orientated projects", says Jesper Buus Nielsen.

The sugar beet project has resulted in a spin-off company. Read the story on pages 46-47

5 CRYPTOGRAPHY & SECURITY

PHOTO: JESPER VOLDGAARD

The mobile phone is opening doors

THE GOAL OF THE RESEARCH PROJECT ITSCI (IT SECURITY FOR CITIZENS) IS TO MAKE IT SECURITY USER-FRIENDLY AND MOBILE.

BY BJARKE ROSENBECK

Current IT security solutions have the weakness of not being mobile. For example, online banking signatures are associated with specific PCs; this is why all information is assembled at a single location. This does not only make online banking less flexible, it also makes it less secure as a hacker would only need to break into a single location in order to gain access to sensitive personal data.

The mobile phone as the key

In this area the ITSCI project can make a difference. The project is a collaboration between researchers in Cryptology and HCI (Human-Computer Interaction) and the research group has already produced the initial version of a prototype, which will increase security considerably.

"By placing one part of the important, personal data on the mobile phone and the other on a central server, there will be no loss of data should the phone be stolen or hacked into, which is currently the case with stationary PCs", explains Niels Mathiasen, who is associated with the ITSCI project as a PhD student.

The project therefore works as a two-stage solution in which the increased secu rity currently consists of the user controlling one side of the process using his or her mobile phone, which in this way acts as a mobile "key". The communication between the mobile phone and the central server is via a Bluetooth connection to a computer.

User involvement as a method

The goal of the ITSCI project is not only to increase IT security by means of modern cryptological methods. The product must also be secure in usage.

Niels Mathiasen is working specifically on thinking user patterns and reactions into the design process. He is therefore working on a method to analyse everyday citizens' usage of secure systems.

One of his theses is that the security procedures themselves must be made more tangible to users and one way of achieving this is to imitate some of the physical security mechanisms we as citizens have already incorporated into our lives and in which we have faith.

"We all know that when we lock our front doors we must hear a click before it is actually locked. If we do not hear this click, we cannot be certain that the door it actually locked, and will attempt to lock it again until we hear the correct sound", says Niels Mathiasen.

"We are working with some similar mechanisms in the ITSCI project. In the same way as with a key, the user must also have a sense of when the IT that he or she is using is secure and functional, and thereby have faith in it", says Niels Mathiasen.

He explains that you could for example stop a bank transaction by removing your telephone from the PC with which the telephone is to communicate and in this way, through a physical act, feel that you have control over the situation and therefore not be nervous about an unwanted transaction having been completed.

To SMS about IT security

Researchers gather the necessary information about users of IT security through qualitative pilot studies. They have therefore engaged eight ordinary citizens for a short period of time. In various everyday situations they are to report back to the research group when they encounter IT that requires security and give an account of how they experience these specific situations.

"We have prepared the ground for our respondents to send us their immediate reactions via SMS and MMS", says Niels Mathiasen, who in this way expects to generate information about ordinary citizens' perceptions of IT security in everyday situations.

> "We all know that when we lock our front doors we must hear a click before it is actually locked. If we do not hear this click, we cannot be certain that the door it actually locked, and will attempt to lock it again until we hear the correct sound"

The ITSCI project started in 2007 and will continue until 2010. However, it can be expected that the products developed by this group could be implemented into the everyday life of citizens within the next couple of years.

"Developments are certainly moving in the direction of telephones having ever increasing capabilities, so I believe that we will soon have an infrastructure that will be adequate for our solutions", says Niels Mathiasen.

Read more about Niels and his prototype on page 8

6

HUMAN COMPUTER INTERACTION

THE RESEARCH GROUP

PHOTO: JESPER VOLDGAARD

HCI-RESEARCH DOES NOT END WITH GADGETS

A large research group forms the cornerstone in a productive, dynamic and flat-structured research environment within the area of Human Computer Interaction at the Department of Computer Science at Aarhus University.

BY BJARKE ROSENBECK

Behind piles of paper, with books on every inch of the shelves, computers and small gadgets on the desk Professor Susanne Bødker is reviewing the latest research within the area of Human Computer Interaction.

"Most importantly we are all becoming better at placing demands on technology", says Susanne Bødker, who is a professor and one of the leading researchers in the Department of Computer Science's group for Human Computer Interaction.

> "Most importantly we are all becoming better at placing demands on technology"

The research group Human Computer Interaction started with a research focus on system development and system development methods. Since the early 1980s the interaction between humans and computers has, however, been the focal point for the HCI group. Susanne Bødker describes how a notion within HCI internationally prevailed in the 1980s that what was of most interest to researchers was to understand what was going on inside users' heads.

"At Aarhus University we focus on what actually happens in the interaction between the human user and the technology and attempt to conceptualise and work with this methodically. We have had a relatively high international profile in this area", states the professor.

The background of the success of HCI at Aarhus University is to be found in a dynamic organisation. As a research group its members certainly insist on the group element in order to avoid a single professor taking all the decisions and the rest of the group following the conductor's baton.

By maintaining one group it is possible to continually shuffle the cards and redeploy people internally within the group. The fact that the HCI group obtains the bulk of its financing through externally financed projects, only further stimulates the manifold creativity that characterises its activities.

More than just gadgets

"Human-Computer interaction is not about inventing gadgets", states Susanne Bødker and continues,

"Prototypes are brilliant at stimulating people's general fantacy. In the HCI group we do not primarily work to build products. We take up the challenges from the projects that they are working on to build various prototypes. A prototype often opens up new issues and challenges for the computer scientists, and it provides alternative ways of thinking and acting for the users in question", says Susanne Bødker.

"Sometimes the prototype gives rise to more fundamental technological breakthroughs", she explains.

The prototype thereby becomes the first small step in the work on new theoretical and methodical challenges for the computer scientists.

> "Sometimes the prototype gives rise to more fundamental technological breakthroughs"

While normal citizens see the newest technology in the commercial world as fascinating and enthralling, a large group of researchers at the Department of Computer Science in Århus are ready and waiting to take the next step into a future in which the interaction between humans and machines will once again move the boundaries between humans and computers.

The majority of the researchers from the HCI group are involved in Interactive Spaces, see pages 28-33

Several research projects from the HCI group have resulted in spin-off companies. Read more about some of these companies on pages 46-55

Clemens rethinks the prevailing

SOFTWARE ARCHITECTURE

BY BJARKE ROSENBECK

PHOTO: JESPER VOLDGAARD

6 HUMAN COMPUTER INTERACTION

PhD student, Clemens Nylandsted Klokmose, has created a French connection. Together with Michel Beaudouin-Lafon he is at the cutting edge of what is possible in the interaction with computers' user interfaces.

Clemens Nylandsted Klokmose has set himself a challenge. He will chart new methods, which will enable us to work with the interaction between user interfaces, which will belie the traditional perception of a computer being operated using a mouse, keyboard and a screen.

In collaboration with the French professor, Michel Beaudouin-Lafon, Clemens will conduct research into rethinking the underlying software architecture for modern user interfaces. The research relates to our traditional use of applications when we work on our digital objects and documents.

Clemens admits that his project may sound a little hairy. However, the idea behind the whole project is that the development should make everyday life easier for the user.

"For example, take two programs such as Word and Photoshop. They have a large number of tools that can be used in the layout of a poster. However, if you work in Word you cannot just transfer the document into Photoshop. In some situations files can be converted between the programs, but often you have no other option than to perform image manipulation in Photoshop and transfer the file into Word. This is not particularly desirable", explains Clemens Klokmose.

The toolbox

According to Clemens Klokmose the future no longer belongs to applications such as Word and Photoshop as we know them today.

"In the conceptual universe our focus will shift towards objects and instruments or tools. Will it be possible to achieve a separation between objects and tools, so that they do not have an unnatural dependent relationship?" Meaning that this tool is bound to Photoshop and can only be used on PSD files on a desktop computer.

> "IT IS DIFFICULT TO SAY WHETHER WE ARE BEING COMPLETELY OVER THE TOP OR ARE THE FRONT-RUNNERS IN THIS AREA"

According to Clemens Klokmose the instruments should deal with objects that are otherwise associated with certain types of files. A drawing instrument should be usable on anything that has a surface, he states.

Similarly, as you could transfer your object from your computer to your PDA, you could also move your instruments around as required. The multitude of instruments is quite simply assembled in a digital toolbox and the instruments retrieved as required.

"Photoshop is a large and complex program and normal users do not need all the possibilities provided by the program, so why should they take up space?", asks Clemens Klokmose.

"Now let us take the example of the poster. Imagine you are sitting on a train wanting to be able to scale and move some figures around on the same poster. It is obvious that you can configure your PDA using tools that allow you to perform these simple manoeuvres on the poster", says Clemens.

If Clemens and Michel succeed in developing the toolbox, it will not just be a paradigm shift in the area of user comfort. The project will also have a long-range political perspective. Just as music is today sold on the Internet as individual tracks, this development will aim at a market in which the user chooses and pays for the instruments that he or she needs.

Totally over the top?

The toolbox is at present a project in its development stage in somewhat unknown terrain.

"We are in the process of writing an article about our work for a conference. We have had problems in finding anything similar in other articles. It is difficult to say whether we are being completely over the top or are the front-runners in this area", says Clemens Klokmose and continues,

"When it is completed it would be interesting to see whether I could develop the theory in the direction of a commercially-based project", concludes Clemens Klokmose.

On pages 4-11 you can read about Clemens' tool box and other HCI prototypes

7

THE RESEARCH GROUP

MODELLING & VALIDATION OF DISTRIBUTED SYSTEMS

PHOTO: JESPER VOLDGAARD

SMART MODELS OF SMART NETWORKS

BY PETER GAMMELBY

Mobile units, sensors or computers linked in a network. Everybody has a need for communication, a need that the research group Modelling and Validation of Distributed Systems has specialised in addressing.

A distributed system is one in which the failure of a computer you didn't even know existed can render your own computer unusable."

The quotation from the American Professor of Computer Science Leslie Lamport nicely expounds what the research group Modelling and Validation of Distributed Systems is all about.

A more precise definition of distributed systems is hardware or software components located on network-linked computers that communicate and coordinate their actions exclusively by sending messages to each other. For example, this can be a sensor network or infrastructure such as the one that forms the basis for the Internet.

The research group is working specifically on developing languages that can be used to create models of distributed systems. The models can then be used to analyse systems before they are put into operation, to see whether they do what they are supposed to with regards to functionality and efficiency.

Now with colours

CPN stands for Coloured Petri Nets; a Petri Net is a graphic and mathematic modelling language named after the German researcher Carl Adam Petri, who presented the Petri Net language in his PhD thesis in 1962. The research group's (or more precisely: The group's present leader, Kurt Jensen's) contribution was initially to improve the language to become a so-called 'high-level Petri Net language' and thus called it 'Coloured', even though it does not actually have anything to do with colours.

" For many years we have developed computer tools that support coloured Petri Nets in practice. These tools make it possible to construct and analyse Coloured Petri Nets models. Therefore CPN Tools has some similarity to a combined CAD and simulator tool", explains Assoc. Prof. and PhD Lars Michael Kristensen from the research group.

CPN Tools is currently distributed free of charge to 7,000 licence holders in over 100 countries and has been in use since 2002. In addition, the group has used it in a large number of industrial collaborative projects with companies, including Ericsson, Nokia and the Australian military.

> " The group's contribution was initially to improve the language to become a so-called 'high-level Petri Net language' and thus called it 'Coloured', even though it does not actually have anything to do with colours "

The group continues to work on the development of Petri Net software in order to automatically take the next step, and contributes more directly to the implementation of the software for which it is a model.

"We can save time and money on this if we can get it to work. We had a meeting in France in August with Texas Instruments, who shows an interest in our approach, so at the moment we have a small pilot project running in order to get to know each other", states Lars Michael Kristensen.

From node to node

Whilst the group is best known for modelling and validation of distributed systems, the hottest topic that the group is currently researching is the development of protocols for mobile ad hoc networks.

It is based on the development of communication protocols and software that can be used in network of mobile nodes (e.g. laptops, telephones or sensors), which can exchange data via the network that they themselves form – and therefore not via the Intranet or Internet.

"We are working with communication networks where not all of the nodes are able to reach each other, but with the aid of software individual nodes can come into contact with the nodes furthest away via the nodes that are located between them. For example, this can be used in mobile units in the military, where you drive in an area without infrastructure, or in sensors in agriculture or industry", says Lars Michael Kristensen.

In the development of ad hoc networks, CPN technology is naturally used to design and verify the protocols for the software.

The research group consists of three permanent members of staff: Professor Kurt Jensen, Associate Professor Søren Christensen and Lars Michael Kristensen. There are also two post docs, four PhD students, a student programmer and a number of Master's thesis students.

On page 6 you can read about how positioning technology helps prison personnel in their daily work.

PhD Morten Tranberg Hansen is involved in the development of wireless sensors for concrete construction projects, see page 26

Everything that can go wrong will go wrong. If we want to avoid falling victim to Murphy's notorious law we have to ensure that nothing can go wrong.

A S A P

BY PETER GAMMELBY

The goal of ASAP is to ensure that nothing can go wrong in regards to the development of protocols and data communication for distributed systems.

ASAP is a validation computer tool that can be used to analyse the protocol models or program models that have been created using CPN tools in order to ensure that all of the conceivable ways in which the system can behave have been taken into consideration.

> "When a system crashes something must have occurred that have not been simulated"

When a system crashes, even if a large number of simulations have previously been run on models of the system, something must have occurred that have not been simulated.

A thorough simulation

ASAP is an abbreviation of ASCoVeCo State Space Analysis Platform and has its origin in a three year research project ASCoVeCO (Advanced State Space Methods and Computer tools for Verification of Communication Protocols), which a team headed by Lars Michael Kristensen has been working on since September 2006 with support from the Danish Research Council for Technology and Production Sciences (FTP).

"With CPN, models can be constructed in a simulator in steps and a multitude of simulations can then be run, but this is not sufficient in order to know whether the system is completely ready for use since there can be executions that have not be simulated. With ASAP, a thorough simulation can be performed as it is possible to calculate all of the possible ways in which the design of the system can behave. We are therefore moving from great faith to certainty, because when you know that you have covered all of the possible scenarios, you also know with 100 percent certainty that the system will not deadlock, for example", explains Lars Michael Kristensen.

It is all about common sense

Lars Michael Kristensen adds that there will always be a limit to this certainty since you are analysing and running simulations of models. The models are not a one-to-one representation of the real system.

"However, you can control how close to reality the models and simulations are to be. It is all about being able to analyse within a reasonable period of time and obtain sufficiently accurate results", he says.

> "It is all about being able to analyse within a reasonable period of time and obtain sufficiently accurate results"

The research team began to distribute ASAP in the summer of 2008 in a Beta version as the development had not at that time been completed.

In the longer perspective, the result will probably be that CPN Tools will be "fused" into ASAP so that a total package can be offered, which can be used by both software and hardware developers.

In addition to this, Lars Michael Kristensen received the "Young Elite Researcher's Award" of the Danish Council for Independent Research in 2007 for his research into computer models.

7

MODELLING & VALIDATION OF DISTRIBUTED SYSTEMS

reaches the edges

PHOTO: JESPER VOLDGAARD

8

PROGRAMMING LANGUAGES & FORMAL MODELS

THE RESEARCH GROUP

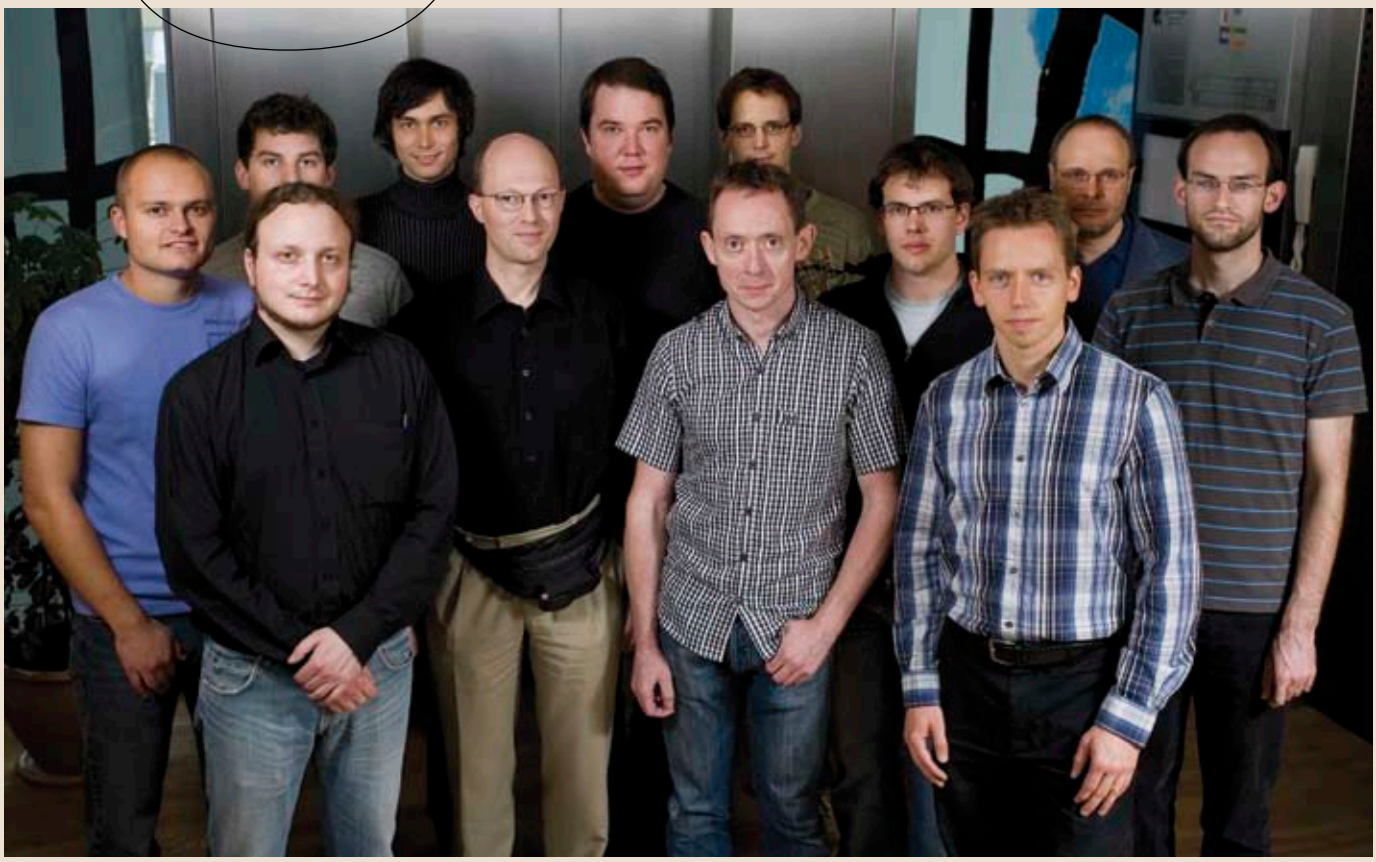


PHOTO: JESPER VOLDGAARD

EASING THE LIFE OF PROGRAMMERS

The life of a programmer is not always easy. Fortunately there are people in the Programming Language and Formal Methods group at the Department of Computer Science at Aarhus University who are working hard to make life a little easier.

BY STIG ANDERSEN

The overall goal of the Programming Language and Formal Methods group is to develop methods to optimise and increase the efficiency of programming languages and ultimately make the programming process itself more efficient. Klaus Ostermann, who is Associate Professor at the Department of Computer Science, explains the types of challenges that programmers currently encounter,

"Inadequate modularity is a typical problem in the existing programming languages. It is very important to be able to delegate the programming work to a number of programmers and at the same time ensure that individual parts of the code interact correctly as a whole. If we can develop some well-defined modules, we would optimise the work process without jeopardising the quality of the final product".

Achieving modularity is a classic computer science dream, of which there are many versions. Klaus Ostermann was recently granted DKK 10 million by the European Research Council to conduct a research project by the name of "ScalPL – A Scalable Programming Language". Today different languages are used for different domains – HTML for websites, SQL for databases, etc. The goal of the ScalPL project is to develop a single programming language that allows programmers to develop domain-specific programs.

> "Our goal is to design a language to design language"

"Our goal is to design a language to design languages. Previously attempts have been made to develop general programming languages, but they were not really powerful enough to satisfy the requirements of domain-specific programming. Our goal is to define a general language that at the same time has the necessary abstract mechanisms for individual domains", explains Klaus Ostermann.

More than technology

The group works on several fronts in order to optimise programming languages. Michael Scwartzbach and Anders Møller work on the development of methods to analyse software so that potential security breaches and sources of errors can be identified. Olivier Danvy works specifically on transformations of functional programs that can be used to analyse compilers, for example.

According to Klaus Ostermann, the work with programming languages is unbelievably interesting as it overlaps with many other disciplines such as logic, mathematics, philosophy and linguistics. Or as he expresses,

"Basically you are confronted with the very fundamental question: What can we actually express using the languages available today? And this is a question that extends far beyond a narrow technological view.

The group's research results have the potential to reach far beyond the walls of the Department of Computer Science. If a new feature finds its way to one of the established programming languages, thousands of programmers will benefit from this. A good example of this is Assoc. Prof. Erik Ernst's research results within the application of wildcards.

boolean addAll(Collection<? extends E> c)

PHOTO: JESPER VOLDGAARD

TAKE A GOOD LOOK AT **THE QUESTION MARK** IN THE HEADLINE. IT DOES NOT LOOK LIKE MUCH, BUT THIS IS THE RESULT OF A MULTI-YEAR JAVA WILDCARD PROJECT, WHICH WAS CONDUCTED BY PARTICIPANTS FROM THE DEPARTMENT OF COMPUTER SCIENCE AT AARHUS UNIVERSITY AND SUN MICROSYSTEMS WITH THE SUPPORT OF THE ALEXANDRA INSTITUTE.

BY STIG ANDERSEN

In 2004 Sun Microsystems released Java version 1,5. This was an important version as it introduced type arguments and wildcards as part of the syntax. The opportunity of using wildcards in Java was the result of research and development driven by Mads Torgersen and Erik Ernst, who at the time were both associated with the Object-Oriented Software Systems group at the Department of Computer Science, and who are currently working at Microsoft and in the Programming Language & Formal Methods group, respectively. Mads Torgersen and Erik Ernst worked closely together with Gilad Bracha, who in those days had primary responsibility at Sun for The Java Language Specification. Erik Ernst says:

> "The innovation was that the wildcards were so general that they also covered existential types. This meant that it became possible to name an unknown type and then treat it consistently in the code"

"It all starts with the developments that have taken place in Scandinavia in the area of object-oriented languages. This was an environment that was concerned with experimental type systems and also virtual classes. Out of this work came the idea of giving greater freedom to type arguments for classes, so that, for example, you did not need to define "a list of strings", rather just a "list of something" that would then be given a value at runtime.

> "It has certainly contributed to making life easier for the developers who work in Java"

Easier lives for developers

The innovation was that the wildcards were so general that they also covered existential types. This meant that it became possible to name an unknown type and then treat it consistently in the code. And according to Erik Ernst, this provides programmers with a number of advantages.

"Without the use of wildcards the code quite simply becomes more complex and requires additional code lines. The reason is that without the use of wildcards there would be much more information available at the time of compilation, if you want to avoid running into type faults. So this has certainly contributed to making life easier for the developers who work in Java.

Wildcards make type soundness

The introduction of wildcards into Java was the result of an experimental approach to the problem. Then came the work of formalising the model, which has been conducted in collaboration between Erik Ernst and researchers from the Imperial College in London. And the work has progressed well. What can be termed a complete formalisation of the language design has now been published, which makes wildcards expressed using existential types possible. And the formalisation is not specific to Java.

"The formalisation is generic in the sense that we have compiled complete evidence showing that the procedure using wildcards is robust. Or in other words, that the consistency that we call "type soundness", can be achieved in a context in which wildcards are used", explains Erik Ernst.

According to Erik Ernst the most important result of the research was to demonstrate that wildcards are full-fledged existential types. And improved user-friendliness when using wildcards is also important. The traditional mechanisms of naming an unknown type variable require that you write much code, and this becomes superfluous if you have the option of using wildcards.

9

THE RESEARCH GROUP

COMPUTER GRAPHICS & SCIENTIFIC COMPUTING

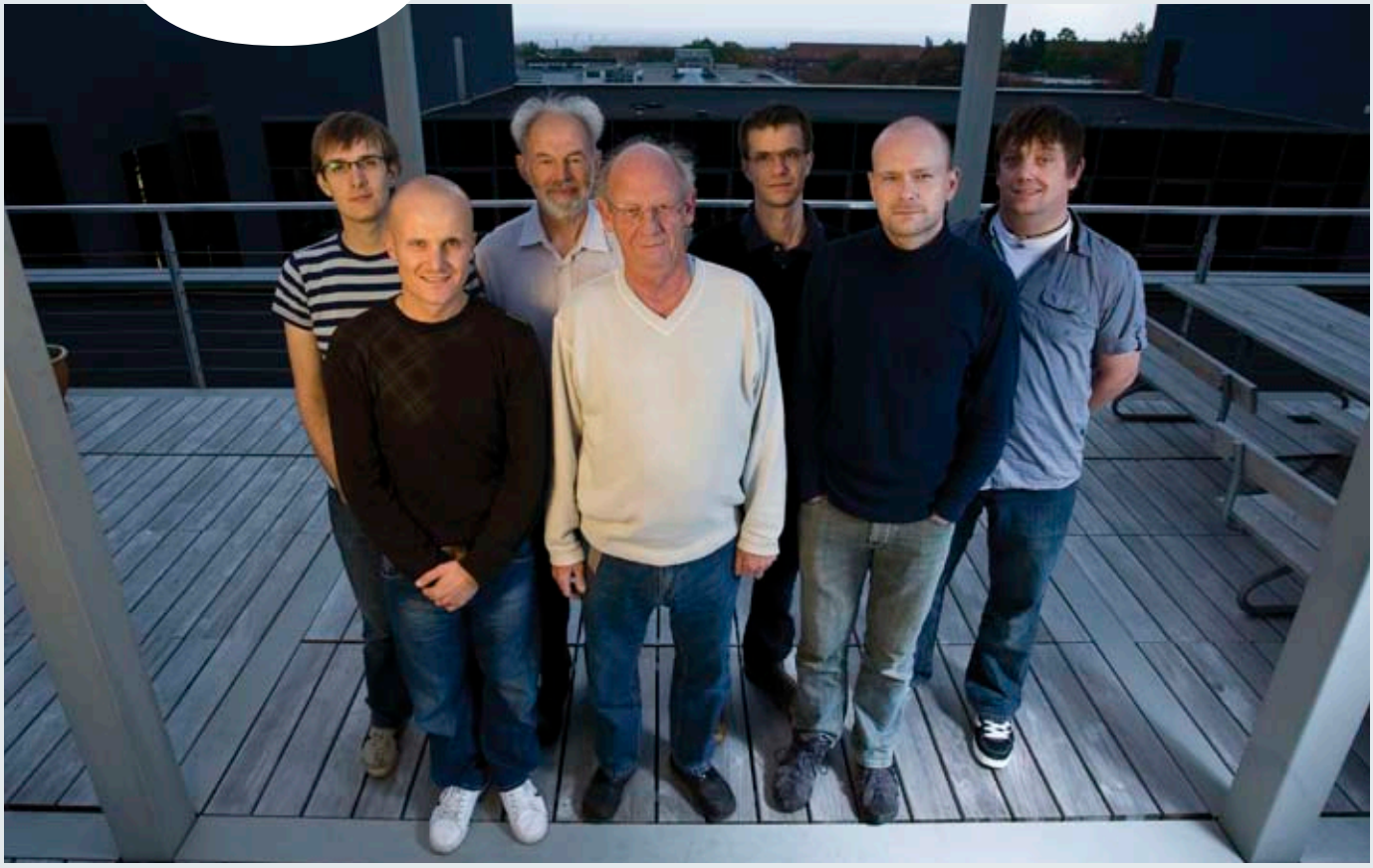


PHOTO: JESPER VOLDGAARD

GRAPHICS CARDS DEFORM HEART TISSUE

RESEARCHERS ARE USING GRAPHICS CARD'S LARGE AMOUNT OF PROCESSING POWER TO CREATE A SURGICAL SIMULATOR FOR DOCTORS.

BY PETER GAMMELBY

How do you create a computer visualisation of a congenitally malformed heart, and a simulation of its repair of such good quality that the surgeon is guaranteed not to receive any unpleasant surprises during the operation?

The answer is by using powerful graphics cards of the type that hardcore gamers have in their computers.

The answer comes from the research group Medical Visualisation and Simulation, which is part of Computer Graphics & Scientific Computing at the Department of Computer Science at Aarhus University.

The newest graphics cards can both create advanced visualisations and physical simulations – the latter most often many times faster than the computer's CPU, which researchers around the world have been using previously.

In this way it is possible to create real time 3D graphics based on the images from e.g. CT, PET or ultrasound scanners.

Elastic tissue

Tissue is elastic and changes form when it is pushed or pulled. This is also the case for the 3D renderings – that is, when using digital scalpels, forceps and tongs.

The surgeon can thereby make surgical incisions, "pull" heart tissue to the side and look into the patient's heart chambers on his computer, and in this way carefully plan the correct operation on individualised heart models.

The group has just conducted a study at a children's hospital in London to investigate whether the patient-specific 3D models can be created in a reasonable period of time and are sufficiently accurate.

"We tested it on 40 patients and it showed that we were able to create a sufficiently accurate model of a patient's heart in an average of an hour. The surgeons can therefore have faith in the fact that what they see in the 3D model is also what they will see, when they open the patient's heart", says Assoc. Prof. Thomas Sangild Sørensen, who is a computer scientist and has a PhD in medicine.

"Many different groups around the world are working with surgical simulation, and one of the greatest challenges is to perform the simulation in real time,

> "We tested it on 40 patients and it showed that we were able to create a sufficiently accurate model of a patient's heart in an average of an hour"

while at the same time maintaining the level of detail sufficiently high. We have found a solution to the tissue deformation problem, which can be resolved by using parallel calculations on the graphics cards; they have a large number of processors that can each deal with their tasks simultaneously, and therefore everything happens e.g. 50 times faster than using just the CPU, as the new gaming graphics cards have several hundred processors".

"We were among the first to use graphics cards as parallel processors for surgical simulation", adds Thomas Sangild Sørensen, who together with three PhD students, Karsten Østergaard Noe, Allan Rasmusson and Lau Brix, currently make up the research group Medical Visualisation and Simulation. A former PhD student, Jesper Mosegaard, now employed at the Alexandra Institute, participated in the development of the cardiac surgical simulator.

Cycling in the scanner

Most recently the group has worked intensively on advanced real time reconstruction of real time 2D image data from MRI scanners.

Today, the best to be achieved from an MRI scan is a couple of images per second of poor resolution. Alternatively, the patient needs to hold his or her breath for ten seconds in order to achieve a high resolution image. If we wish to record and reconstruct images with both good spatial and temporal resolution, complicated mathematics and an effective implementation are required in order to reconstruct the images as fast as data is recorded.

"Our vision is to be able to create 20 images per second of high resolution. We can already do this now in the laboratory using our algorithms and graphics cards. This will open up a wealth of new clinical opportunities, especially since we will be able to see sharp images of moving objects. For example, you could "cycle" inside the scanner, and the scanner will be able to show how your physiology changes", says Thomas Sangild Sørensen.

The group is collaborating with computer scientists, engineers, physicists and doctors at hospitals in Aarhus, Bordeaux and London, and expects that the system will be able to be run on all scanners in the future.

GRAPHICS with Waves and Smoke

Århus does not look much like Hollywood on a grey autumn's day. However, this does not prevent members of the research group Computer Graphics & Scientific Computing from delivering "state of the art" software that generates visual effects in the biggest Hollywood films.

PHOTO: PETER GAMMELBY

9 COMPUTER GRAPHICS & SCIENTIFIC COMPUTING

BY PETER GAMMELBY

How do you make water flow exactly the way you want it to? In the real world pumps, channels and dams can be used, but if the water consists of the figures zeros and ones in a computer program equations must be used.

Making fluids (and smoke for that matter) behave naturally and at the same time being able to control how the water and smoke behave, is one of the main activities of the Computer Graphics & Scientific Computing unit within the Department of Computer Science at Aarhus University.

The three members of the research group Physically Based Simulation of Surfaces and Fluids have already come a long way; one of them, Adjunct Professor Ken Museth, is now permanently employed by Digital Domain in Hollywood, where he assists in the development of computer-animated special effects. He provided the software to imitate water spray in the film Pirates of the Caribbean III, among other things.

The second is Post Doc Michael Bang Nielsen, who is based in the Ada Building in Katrinebjerg, and the third is Brian Bunch Christensen, who has been living in Hollywood since mid August where Ken Museth is his supervisor for his PhD thesis.

Skype is therefore an important tool for this small group.

Physics needs to be controlled

However, the most important tools are physics and mathematics, which are behind the equations that the group slogs away to develop.

"For artists who create visual effects, smoke and water are difficult to control. Physical equations are used to simulate smoke and water since both phenomena contain so many details that it is difficult to model them manually. When using equations, you obey the laws of physics. However, when the water or smoke obeys the laws of physics it is not always the case that they behave exactly as the artists would have preferred. We are working on developing a system in which equations and modelling interact, so that the artists can control which way the water will flow", says Michael Bang Nielsen.

> "WE ARE WORKING ON DEVELOPING A SYSTEM IN WHICH EQUATIONS AND MODELLING INTERACT, SO THAT THE ARTISTS CAN CONTROL WHICH WAY THE WATER WILL FLOW"

When you create scenes using water or smoke, you start by finding the correct look in a coarse resolution, and then you increase the resolution and include the fine details. However, since the equations are very complex, a completely different result is often obtained, where the water or smoke does not behave as it did in the coarse resolution.

"Our project attempts to retain the behaviour from the coarse resolution in the high resolution. We have developed a number of modifications to the original equations, making them longer and more complex, but where it is possible to control them", explains Brian Bunch Christensen over a Skype connection.

Smart algorithms

The group is working simultaneously on another project, "Highres levelsets", which is all about increasing the resolution of graphic simulations of surfaces using I/O algorithms, thereby minimising the traffic to and from the hard disc. In this way simulations can e.g. be run quickly on laptops with only 1 GB RAM, even if the data consumes 18 GB.

"It is meant for scientific computing where these algorithms can be used to perform large calculations on small machines. It is not intended for gaming or film production", says Michael Bang Nielsen.

An example of the equations used by the group to simulate water and smoke:

$$\frac{\partial u}{\partial t} = -(u \cdot \nabla)\, u - \nabla p + f$$
$$\nabla \cdot u = 0$$

The equations are called "Incompressible Euler equations". It is U that is solved for. U is a vector field or velocity field that describes how the fluid moves. U is dependent on time, t, and the position in space (x, y, z). P is the pressure of the fluid, while f is the external forces such as gravity.

Computer Scientists

The Computer Science education is broad and the trained computer scientists therefore take up many different positions by the end of their studies. Four computer scientists talk about their current jobs, and how they in their daily lives make use of the competences acquired through their studies.

MICHAEL SVANHOLM THOMSEN

35 years old, Lead Program Manager, Microsoft Dynamics NAV Server & Tools, Microsoft Developer Division, PhD 2002

What is your specialization?
"I have always primarily been interested in the application of IT, so I spent most of my time in the experimental branch. During the course of my PhD I worked with tools and techniques for collaborative and iterative system development".

What are you working on now?
"I work in the Microsoft Development Center Copenhagen. In fact it is Microsoft's largest development site in Europe. My team designs and requirement-specifies the whole platform for Microsoft Dynamics NAV. We collaborate with other Microsoft teams and with developers and testers who realise our designs and requirements. There are approx. 900 employees from 40 different countries on the site, which contributes to a fantastic richness of different personal competences".

What have you gained from your studies that you use in your daily work?
"A great deal! The product that we are developing contains all of the classic IT components from our own programming language, our own IDE, our own Server, etc. So I can actually draw on tangible knowledge from almost all of the courses I have had".

ARAZ BAYAT MAKOO

28 years old, Team Leader EPJ, Systematic A/S, MSc. 2006

What is your specialization?
"I wrote my dissertation in cryptology with the title: 'Transforming Private-key Encryption into Public-key Encryption using Obfuscation.' So you could say that it was a very theoretical dissertation".

What are you working on now?
"After 18 months as a system developer at Systematic I was asked if I felt like grappling with the leader role. So now I am a team leader for a team of 13 computer scientists and engineers that work on the development of the Electronic Patient Notes (Den Elektroniske Patientjournal) for the former County of Århus. Actually I have not been involved with cryptology at all since I graduated and I occasionally miss becoming absorbed in a subject. In the world of business you are controlled by the customers' demands. But I am happy with my job as Systematic really focuses on personal development, so I learn a lot about communication, personnel management and planning. Just now, for example, I am following Systematic's project manager course".

What have you gained from your studies that you use in your daily work?
"It is a great advantage that I have a thorough understanding of the challenges facing computer science in the projects. My task is to deal with the problems that are associated with the implementation of the IT projects, and my education has clearly helped me to qualify for this. However, much of what I have learned through my studies is too theoretical to be used in the world of business. In practice I primarily use my knowledge in areas such as programming, algorithms and data structure".

at Work < < <<<

BY MARIA ØSTER

AINO VONGE CORRY

37 years old, Technical Conference Editor, Trifork, PhD 2001

What is your specialization?
"I wrote my PhD thesis in Design Patterns. This is a method to communicate experiences of good system development. I also worked on the differences between object-oriented programming languages".

What are you working on now?
"I am working for Trifork, where I have many different functions. The majority of my time is spent on planning the technical program for our JAOO and Qcon conferences in Århus, San Francisco, Australia and London. This is very exciting and keeps me abreast of the latest technology. I also teach software developers from other IT companies in object-oriented system development and Java. In addition to this, I help other software development companies to improve their methods of developing software via the Retrospectives method".

What have you gained from your studies that you use in your daily work?
"My studies covered many subjects. Everything from user interfaces to databases, cryptology and algorithms. The broad understanding of subjects and the relationship between them enables me to assess which subjects should be included in our conferences. I would not have been able to teach object-oriented design if I had not acquired thorough knowledge of the subject through my studies".

MICHAEL ØSTERGAARD

29 years old, Research and Development, Lenio A/S, PhD 2008

What is your specialization?
"I wrote my PhD thesis in cryptology focusing on privacy and digital signatures".

What are you working on now?
"I am employed by Lenio, where I work on developing products for security. Today I am exploring the opportunities for products to protect personal details in conjunction with authentication. We work on user control of information provided in specific contexts. For example, with "Young person's ID", young people can specify the required age on the Internet in order to access a specific website. The idea can also be transferred to the physical world in the form of an integrated identity card, where the individual controls the information that he provides, e.g. whether he is old enough to enter a specific disco. In this way, no details such as name, CPR no. etc. are disclosed. "I decided to take this route as I find great fun in working with people using technology in practice. Researching is completely different from actually having to go out and talk to customers".

What have you gained from your studies that you use in your daily work?
"The studies have enabled me to get acquainted with everything related to technology. I have studied many different subjects, which means that I am always prepared for the challenges I encounter".

STUDY IT OR COMPUTER SCIENCE

> The Department of Computer Science is located in the IT Park Katrinebjerg, where Aarhus University has gathered all available IT educations and IT research.

> With approx. 1800 students and more than 200 researchers it is the largest IT study environment in the country.

> Each year approx. 100 new students start on a Bachelor programme in Computer Science and 40 on a Bachelor programme in IT.

> In addition to a Master's programme and a PhD in computer science, a two-year graduate programme in technical IT is being offered: The programme is organised in collaboration with the School of Engineering in Århus. The Department of Computer Science also includes Diploma and Master's programmes in Software Construction.

Read more about the programmes on the Department of Computer Science's website, **cs.au.dk**, or on the Aarhus University study guide, **studieguide.au.dk.**

DEPARTMENT OF
COMPUTER SCIENCE
FACULTY OF SCIENCE
AARHUS UNIVERSITY

The Department
of Computer Science
Aarhus University
The IT Park, Åbogade 34
DK-8200 Århus N
Tel: 89 42 56 00
Fax: 89 42 56 01
e-mail: info@cs.au.dk

cs.au.dk