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High octane know-how for companies of the future

In just a few years CISS has shown that the centre, its staff and those studying for their PhD can "deliver the goods" when it comes to providing a significant technological boost to Danish industry.

We surround ourselves with embedded software it is to be found everywhere in our daily lives and throughout the world. It is present in the mobile telephone, the electronic bathroom scales and in aircraft and communication satellites. That's a fact.

It is also a fact that the area of embedded software systems is an area in which Danish companies can lead the technological field. This, however, requires that research and development is carried out with a high level of co-operation between the research institute and the individual companies concerned. It is for this reason that CISS (Centre for Embedded Software Systems) at Aalborg University, having only existed a couple of years, is on the road to becoming an established sparring partner for companies of all sizes.

Kim Guldstrand Larsen, Director, CISS

Know-how available

"CISS did not arise from nothing. Three groups of specialists from two different institutes are collaborating at CISS. These are "Distributed Systems and Semantics" from the Institute of Computer Science and "Distributed Real-Time Systems" and "Embedded Systems" from the Institute of Electronic Systems," explains Kim Guldstrand Larsen, Director of CISS. He continues, "Each of us has brought to CISS all the knowledge we have gained through many years of research. This means that we can offer companies something which they can't buy anywhere else. Apart from this our organisation has an in-built flexibility which benefits our partners."

To the question of what else distinguishes CISS when compared with other skills providers, Kim Guldstrand Larsen answers, "It's our interdisciplinary structure! Engineers and computer scientists working closely together - that's unique. This means that we cover a very broad spectrum, we can become absorbed in a single detail – but we can also contribute to the whole development process!"

20 projects on the go

CISS came into existence as an IT skills centre under the Jutland and Funen IT drive. The first step was taken in 2001 when North Jutland County Council and Aalborg Municipal Council combined to provide a grant of DKK 700,000. One year after this, in September 2002, CISS was given the official seal of approval as a four-year research project in the shape of DKK 25.5 million from the Danish Ministry of Science, Technology and Innovation. Armed with a further grant from the municipal and county councils of DKK 6 million each, joint financing from Aalborg University - and expected joint financing from private companies -CISS was able to embark on its first official project year - 2003.

"At this time though we were already well on the way. The grant from the county and the municipality the year before had had the effect of kickstarting the process which is part of the explanation for the fact that CISS is as well established as it is - here, only halfway through the project period," points out Kim Guldstrand Larsen.

So far CISS has been instrumental in setting up a total of 20 joint projects in partnership with companies - and at this point in time there are 14 projects together with a great deal of research surrounding these projects. Research which will, without doubt, be of benefit to future partners.

Read more about CISS, its projects and partnership possibilities on the following pages!



The future is calling ...

We are only now getting used to communicating live images with the mobile phone and witnessing discussions about the dangers of radiation, but for researchers at CISS, 3G technology is ancient history. They are heavily engaged in developing the next generation.

"Can you imagine all the electrical devices now available being in constant contact with each other and each individual apparatus always knowing its own location?" Associate Professor Peter Koch attempts to paint a mental picture of the coming generation of telecommunications technology, which is not all that easy as no standards have yet been determined for 4G technology.

"Everyone is busy developing and breaking new ground, but the large majority agree that making information accessible anytime and anywhere is what it's all about," says Peter Koch.

Adapt and optimise

Aalborg University is among the forerunners concerning research and development within the area of 4G technology. It is CTIF (Centre for Tele-Infrastructure) which co-ordinates the work but a small part of the big picture rests in the hands of two PhD students at CISS.

"To put it simply, our work can be split up into two parts. We try to develop algorithms that can contribute in defining 4G technology. At the same time we ensure that the algorithms may be implemented inexpensively and efficiently in the hardware we expect to form the devices of the future," says PhD Student Søren Skovgaard Christensen.

The best compromise

It is his colleague Anders Brødløs Olsen who is responsible for making the best use of the power and storage consumption in future electrical devices. "I work with operative systems which determine how quickly things happen, and in which order. It is my job to find the best compromise between the power of computation and the actual requirements as, naturally, there are limited resources in these embedded systems," says Anders Brødløs Olsen.

Uncharted territory

This type of algorithm optimisation and scheduling, as it is called, is nothing knew. The newest thing about it is the fact that everything is being done on the basis of a technology that is not yet fully defined.

"It is expected that 4G technology will utilise existing technologies such as Wireless LAN, UMTS, Bluetooth and maybe even GSM together with newly developed technologies based on OFDM transmission technology. It is a melting pot of all the existing technologies spiced with something new - which is not yet defined. We must, of course, keep this in mind when we are developing the algorithms," says Søren Skovgaard Christensen.

Intuition as a tool

The plan to use completely new technology is of course also something to consider when Anders Brødløs Olsen is faced with making everything run as efficiently as possible.

"Scheduling is, of course, largely about knowledge of methods and experience, but it is also very much about intuition. The importance of intuition increases when we work with new technology where the theories behind some of the previous experiences and methods are no longer relevant. A major part of the work is therefore grounded in following your instincts and then testing to see how well they work," says Anders Brødløs Olsen.

CSS

A computer that understands pig language and can regulate climatic conditions in accordance with the pigs' instructions. This is the ambitious goal for a joint project between the Danish company Skov A/S and CISS.

"Just imagine if we could create a system capable of monitoring and measuring a range of factors and then, on the basis of this data, we were able to ensure optimal conditions for the pigs."

PhD Student Jens Alsted Hansen draws a pig on the board - with a big, handsome and curly tail. Then he starts to tell about the idea which he and a PhD colleague have been working on for about a year.

Animals as sensors

These days, temperature, humidity and a whole range of other climatic factors are measured in the stables in order to obtain the optimal conditions for the pigs. "We would like to expand this system to include observations of the behaviour and condition of the animals so that, in this way, the system will be capable of adjusting itself and ensuring that conditions are optimal," he explains.

This project stems from the fact that stocks of animals at Danish farms have become so large that it is difficult and time-consuming for the farmer to keep an eye on all the animals.

"If a pig lies down it means, as a rule, that it is too hot, but if this pig is the only one out of a thousand pigs who lies down, it can mean that it is ill. This is what we need to be able to observe, and if there is a problem which the system cannot itself deal with, then, the farmer must be called," explains Jens Alsted Hansen.

Benefiting the animals

It is SKOV A/S from Glyngøre, Denmark which is jointly financing the two PhD students' work. A somewhat long-term investment perhaps, but one which offers considerable prospects.

"For a long time we have been convinced that there

are technologies and theories in existence which neither we nor the industry are making use of and just as we finally decided to throw ourselves into researching a new technology, CISS emerged as an industry-related research centre. The basic concept is to integrate "good animal husbandry" into the automated system. In addition to bigger and bigger animal stocks there is, abroad, a tendency to use labour which is less and less skilled. Such a system will therefore not only be of benefit to the animals but also to the farmer, as the animals will develop more satisfactorily which, in turn, will lead to an increase in the quality of the meat," says Martin Riisgaard-Jensen who is the Software Group Manager at Skov A/S.

From concept to reality

The partnership with CISS has been going on for a year and Martin Riisgaard-Jensen is extremely pleased with the results.

"We have had a good dialogue and we have succeeded in making things more concrete. Now we know where we are going, so the next step is to turn it into reality," says Martin Riisgaard-Jensen. The researchers have two more years in which to do this and at Skov, they are in no doubt that the project will be very beneficial.

"Of course, the project will not result in a finished product. At the very best we will have a prototype which can be matured into a product and at the moment I have no doubt that it will be successful. Irrespective of the results we will have gained a great deal of knowledge and experience with which we will be able to continue our work," says Martin Riisgaard-Jensen.

Mathematical models

It is exactly this transition from theory to practice which, as so often before, is the most difficult. The challenge is not so much based in gathering the diverse information. It is when all of these inputs, such as the behavioural patterns of the pigs, surface temperature, body temperature, sound and the absorption of feed, have to be calculated that it begins to resemble maths at a high level. The little pig on the board is quickly encircled by a myriad of complicated calculations.

"The pig has an effect on its surroundings in the same way that temperature etc. has an effect on the pig, and it is all these many connected factors for which we must create a mathematical model. We can begin with the fact that there is a wide range

FACT BOX:

Skov A/S was founded by the brothers Kjeld and Kristen Skov at the manor house of the Østergaard Hovedgaard in Åsted, Denmark, in 1954. Since its foundation the company has grown to become one of the world's leading producers and suppliers of components and systems for stable climate control. Today the company's headquarters are in Glyngøre, Denmark, where there are 200 people employed and from where they serve a network of 75 distributors throughout the world.

of so-called causal factors but, fortunately, we can eliminate a great deal of them. We know, for example, that the air temperature does not change much in the course of a few seconds, so all eventualities for which this would be a pre-requisite can be eliminated. We can, in the same way, eliminate a number of other situations which we know do not occur in the real world. In this way we end up with a number of possible situations with which we can work - though this still represents an enormous number," explains Jens Alsted Hansen.

Big ambitions

Firstly the idea is that all information gathered from the different sensors will be continuously

transmitted to a central computer which, in turn, will determine what needs to be done to ensure that the pigs have the optimal conditions. In the long run, however, our ambitions are bigger than this. "I can envisage each individual little sensor being a mini-computer itself that would be capable of participating in the total calculation. The small computers could, as it were, talk together and jointly determine what needs to be done. This would provide a much higher level of reliability and, in the long run, I am sure that such a system would be less expensive. In my opinion we will not be able to claim to have created an intelligent sensor network until we have achieved this," says Jens Alsted Hansen.



Long-life sensors

An Italian researcher regularly makes the journey from Rome to CISS in Aalborg to ensure that Danish pigs can enjoy an even better interior climate.

Claudio De Persis is an assistant professor at the A. Rupertis Department of Computer and Systems Science at the University of Rome where he specialises in control theory. Approximately once perature, humidity and CO2. Claudio De Persis' task is to ensure that these sensors - which may be wireless and placed at different locations in the stable - are able to function with as little information as possible. That is to say that he has to cut down the amount of data to a minimum so that the system is not overloaded."

"Such wireless sensors are battery-driven. It is therefore important that you don't have to chan-



every three months, however, he leaves Italy and joins CISS to spend some weeks helping Skov A/S - and thus the two PhD students at CISS who are working with Skov - to develop intelligent climatic control systems for their pig stables.

For the time being Claudio De Persis is back in Rome, but Deputy Director Henrik Schiøler tells, "The valves in a stable system which take care of changing the air in the stable are controlled by a number of sensors. These sensors measure temge the batteries all the time - and this is what you would have to do if the system were loaded with large amounts of data. In fact the batteries should be able to last so that they need only be replaced, for example, in connection with cleaning of the complete stable before a new batch of pigs moves in. This means that the batteries should last for at least three months," explains Henrik Schiøler.





PhD Student John Knudsen is "hired out" to various companies. One of them is MAN B&W which wants to determine whether monitoring and control of its gigantic diesel engines can be managed by model-generated software.

"The idea resulted from our determination to be better at communicating our skills and our reliability to, for example, customers and classification societies. A model can illustrate many things which are perhaps difficult to understand when you read a long list of program codes, and as we are working with machines of up to 100,000 hp, it is an advantage to be able to show that things have been properly tested," says Development Engineer Jean Laustsen from MAN B&W.

Reversed process

Together with PhD Student John Knudsen he has, for the past six months, been examining the possibility of utilising model-generated software in the embedded control systems of the diesel engines.

"At the moment we are taking small bites of the existing code and attempting to draw models from that. Then we generate code from the models which we compare with the original code. This is called "reverse engineering" and gives us the possibility of examining the advantages and disadvantages of the model-generated code," says John Knudsen.

Time, money and collaboration

There are great benefits to be gained if we are successful in getting the model-generated software to function with the embedded systems in the diesel engines.

"We can save both time and money if we can produce our software from models and it provides an excellent base on which we can work together. At the model level, we all speak the same language. People developing different types of software can immediately understand each other and we have an easily comprehensible way of explaining things to a third party. It will also be easier to analyse what we are doing and what we should be doing differently. In this way the quality of our software development will improve," says Jean Laustsen.

On the right track

At the moment, though, this work is still at the beginner stage. Use of resources is an especially significant question in connection with model-generated code.

"It has always been said that model-generated code is not suitable for embedded systems because of the need for a very low level of resource consumption. Model-generated code was not at all accepted as being as effective as traditional code. Our job is to prove the opposite - or find a way to correct this imbalance," says John Knudsen. And there is optimism in the B&W camp.

"I am totally convinced that we are on the right track. Working together with John is fantastic, even though we come from different environments and I am absolutely sure we will have an operational prototype when our collaboration comes to an end in two years," says Jean Laustsen.



From left:

Kurt Kirkedal Laursen, Project Manager, Lars Benthin, Department Manager - both from Ericsson Telebit - and PhD Student Saulius Pusinskas, CISS

Managing mobile telephone traffic

A whole new alliance between CISS and Ericsson Telebit is examining the possibilities of automating the testing of the company's "Connectivity Packet Platform" which conveys, monitors and manages mobile data and telecommunication. The success of this could pave the way for a considerable number of other special joint projects.

Ericsson, based in Viby, Denmark, produces cupboard-sized machines which act as a type of "airtraffic controller" at the bottle-necks on the broad communication motorway of mobile telephony. A steady stream of data comes in at one end to be analysed, sorted, prioritised and sent on in the right direction at the other end.

The dramatic developments within mobile telephony means that the machines must be capable of more and more and each time have to be thoroughly tested to ensure that they do not create "traffic jams" in the stream of communication. "We have a long check-list showing everything to be tested on the machines and that list is becoming ever longer in step with the increasing capabilities of our mobile telephones. We have already automated many of the elements, but there are still some areas left which we test more or less manually and we aim, of course, to constantly optimise our test procedure and make it more effective - not only to save time, but also to ensure quality," says Kurt Kirkedal Laursen, Project Manager at Ericsson.

Testing must be adapted

An alliance with CISS will now contribute to this test procedure. Since 1 September 2004, PhD Student Saulius Pusinskas has been attached to Ericsson to help in creating an individually tailored test procedure for the company.

"Some of the larger companies do today offer tools for developing test methods, but these tools are superior. They can assist in the control and monitoring of test procedures so that they can be supplemented by more specific test methods that are specially adapted to our products. It is these specific tests which Saulius will help us to optimise," says Lars Benthin, Department Manager at Ericsson Telebit.

Valuable knowledge

The joint project with CISS began after Ericsson joined Nouhauz which is a knowledge centre under the Department of Computer Science at Aalborg University. In this connection the company was visited by Arne Skou and Kim Guldstrand Larsen who, apart from being computer scientists, are also the Deputy Director and the Director of CISS, respectively.

"Through Arne and Kim we learned about CISS and that one of their particular areas of competence is test and verification. This, in our opinion, is an area which receives all too little attention - also globally. To illustrate this I can tell you that in the USA there is only one single university which actually has test and verification as a specialist area so it would be just fantastic if we could enter into a collaboration with skilled people in this area here in Denmark," says Lars Benthin.

Theory vs. practice

In concrete terms this joint project will mean that Ericsson, in the first instance, jointly finances Saulius Pusinskas' PhD course of study for the next three years. His time will be distributed between his studies and his actual work at the company in Viby. In this way Ericsson gains an insight into the results which his PhD studies produce and Saulius gets a unique opportunity to gain some practical experience in the otherwise theoretical material.

"For me it is a fantastic chance to actually use the things I am working with in a concrete context and to be able to see how they really work. I gain company experience which can contribute positively to my PhD work and which can be of benefit to me at a later stage," says Saulius who originates from Lithuania and came to Denmark to take a master's degree in GPS technology at the Faculty of Engineering and Science at Aalborg University. The people from CISS got to know about him from his work here and he fitted perfectly into the project with Ericsson.

Expanded collaboration

In addition to their skills in the particular area we would like to know more about, CISS are especially good when it comes to thinking in terms of concrete possibilities for applications. They know how to combine the university environment with the realities of the company which results in their research being concrete and useable. I therefore expect that we would be interested in expanding our collaboration with CISS. There are many ways in which we could be of benefit to each other - in terms of the exchange of both know-how and experience so I'm sure we are going to talk to each other a lot more in the future," says Lars Benthin.



The mathematical software manager

PhD Student Anders Jørgensen is in the process of developing a method which can detect software faults while the software is in operation – using mathematics.

"Sometimes we can logically eliminate some of a program's behavioural possibilities by defining them purely mathematically - that is to say, by using equations. So what I'm doing, in short, is developing a method which will make it possible to discover whether an error can be measured when you have the mathematical definition."

Just now it all sounds rather theoretical when Anders Jørgensen explains his PhD assignment. Anders Jørgensen himself is, however, convinced that this will be of benefit to the industry in the space of just a few years. What Anders Jørgensen is doing is aimed at fault-tolerant systems, i.e. systems which MUST not go wrong. This could be hospital equipment for example or direction and communication software for aircraft – or something else entirely.

This makes enormous demands on the manufacturer. It requires that software is tested for all imaginable, and unimaginable, errors both before the apparatus in which the software is embedded leaves the factory – and after it has left the factory. It is the latter which is Anders Jørgensen's primary area.

Graphic models save money

"During the preparations leading up to a new product it is not always enough to think about how it is going to look or work. It is also necessary to consider how reliable the product will be and how errors can be measured. By setting up the mathematical equations for the product you can anticipate whether it will later be possible to measure errors everywhere in the product. That is to say when the product is in operation with the end-user."

"If you are able to see in advance whether an error can be measured over the complete system it is possible in a design phase to test various shapes and designs while at the same time selecting the most cost effective and reliable solution," Anders Jørgensen points out.

Anders Jørgensen is a qualified electronics engineer in intelligent autonomous systems and in connection with the final examination of his course of study in engineering he created a graphic tool to handle the same types of problems, but at that time in connection with hardware systems. Therefore he also has some rather definite opinions about how his project should end up.

"Clearly we researchers should feed industry with the latest wisdom so that they can become even more competitive. In order to do this successfully, however, we must present it to them in the right way. This means that it must be easily accessible and user-friendly – we must keep it simple. Industry should be able to make use of these graphic tools without necessarily having to know a great deal about the theories behind them."

Anders Jørgensen will hand-in his PhD thesis in about eighteen months and companies interested in being attached to Anders Jørgensen's PhD project are invited to contact CISS.



Berit Borup Brendborg, Administration Manager, and Kim Guldstrand Larsen, Director - both from CISS

Hire a researcher

The following answers to questions which companies most frequently ask CISS indicate that hiring a PhD student is plain common sense and that it is also financially advantageous

"Isn't it extremely expensive to hire a PhD student?"

"A partnership agreement with a PhD student costs DKK 1.5 million over a period of three years. Financing functions according to the 1/3 model, i.e. CISS contributes one-third, Aalborg University one-third and the company one-third," explains Berit Borup Brendborg, Administration Manager, CISS, and continues, "This means that the company is down to DKK 500,000 over three years. For companies with less than 250 employees, however, there is a new and attractive scheme which allows a deduction of 150% of the expenditure in tax. This gives an approximate deduction of DKK 250,000 - and so we are down to a monthly expenditure of DKK 7,000 for a researcher. A company cannot engage any other type of employee for this amount of money!"

The company can also include man-hours as part of their own funding of the project and, in this way, reduce the expenditure even further. It is also possible to share a PhD student with other companies if desired.

Easy and safe

"Isn't it difficult to arrange such an agreement?" "Actually no. There are, of course, some application forms which have to be filled out, but we can help with that," says Berit Borup Brendborg.

"We are working with cutting edge technology which means that we are very vulnerable when

Valuable knowledge - inexpensive manpower

it comes to industrial espionage. How do we ensure the confidentiality of a product we are in the process of developing?"

"Every time we enter into a partnership agreement with a company we take into account such things as confidentiality, competition clauses and the rights to the work being carried out at CISS". The company can, for example, make certain reservations in connection with the PhD student's right to work for a competitor after having handed in his/her PhD thesis. In the same way we can elect to postpone the publication of a PhD thesis until such time as the company has applied for a patent," points out Berit Borup Brendborg

The importance of matchmaking

"How can we be sure that we get the researcher who is best equipped to help us?"

"Matchmaking is an absolutely essential process. This is why the deputy directors and I always visit a company together so that we can carry out a joint analysis of the requirements and wishes of the company. We are in a position to know what the various research groups are working with and which new PhD students will be joining us at CISS," explains Kim Guldstrand Larsen, Director, CISS.

"Can we get further information about hiring a PhD student?"

"Yes, a couple of times a year we invite all the companies we have contact with to an information meeting where we tell about such things as collaboration agreements with researchers," tells Kim Guldstrand Larsen, and Berit Borup Brendborg adds, "Companies are also very welcome to contact CISS themselves for further information!"

Plenty of research money available to companies

An annual pool of DKK 167 million is gathering dust at the Ministry of Science, Technology and Innovation. CISS would like to help companies gain access to this pool and, at the same time, give a boost to research and development.

When he was the Minister for Taxation, Mr. Anders Fogh Rasmussen who is now the Prime Minister of Denmark, made a statement saying "Money is gushing out of the Treasury". Today he would be correct in saying: "Money is not gushing nearly fast enough out of the Treasury."

The money the government would like to share out more quickly is the annual pool of DKK 167 million which has been allocated to research in companies.

In practice, companies obtain a 150% deduction on their expenditure in connection with a jointly financed research project with a public research institution and when this scheme, which started in 2002, was extended by a further three years in May 2004, the government held out a special carrot: companies with less than 250 employees also obtain a 150% deduction on their salary costs.

Not research-minded

At the Danish Research Agency which takes care of the practical work involved in managing the 150% pool, they are not particularly overworked. "In the first two years a total of some DKK 32 million was spent. Since the scheme was extended in 2004 we have, to date, received seven applications", reports Knud Gundersen, Senior Consultant at the Danish Research Agency, and goes on, "I believe that the problem - especially in the case of small and medium-sized companies - is that research is not something they think a lot about. They do not consider research part of their world and they do not connect research with development."

The statistics speak for themselves: in 2004, only approximately DKK 18 million of the DKK 167 million available was spent.

Help with the paperwork

At CISS they are convinced that the root of the problem lies in the fact that the companies who can potentially benefit from the scheme, have never heard of it.

"When we present the scheme to, for example, trade promotion officers at the municipal councils they are positively surprised. They have actually never heard of it and they want to get out and give the news to the companies", explains Berit Borup Brendborg, Administration Manager at CISS.

"It is gratifying when CISS - and the universities - promote the scheme", points out Kresten Olesen who is a principal at the Centre for Research and Innovation at the Ministry of Science, Technology and Innovation.

CISS is, however, not content with just informing companies and commercial managers with whom they have contact of the 150% scheme. They also offer to assist in filling out the necessary papers for the ministry.

"This is a definite advantage because, when the papers are filled out correctly, I can promise that they will be processed quickly - typically within eight to fourteen days", promises Knud Gundersen from the Danish Research Agency who looks forward to receiving more applications from North Jutland.

EU involvement in the area of embedded software systems

The first step has been taken towards a major pan-European research centre for embedded software systems. It is called ARTIST2 - and CISS is playing an active part.

ARTIST2 - the Network of Excellence on Embedded Systems Design is, as yet, so new that there has only been time to hold one kick-off meeting which took place in Grenoble, France, in October 2004. The start of ARTIST2, which operates under the EU's sixth framework programme, marks the first step towards building a network of all universities in Europe which are working specifically with embedded software.

Included on the impressive list of participating universities is CISS, Aalborg University.

"The universities have, of course, worked together before - among other things the first ARTIST, under EU's fifth framework programme, produced four so called "roadmaps" which defines the particular areas we want to focus on in the future. We have to start work on this now," explains Kim Guldstrand Larsen, CISS. He goes on:

"The collaboration under the auspices of ARTIST2 will create the possibility for an even bigger targeted effort. We can, for example, carry out research and analyses jointly - across country borders"

Strong response

Kim Guldstrand Larsen does not deny that the networking inherent in ARTIST2 is a necessary response to IT development in Asia and in the USA. "For the benefit of the companies in the EU it is necessary to ensure that we, in terms of research, are properly equipped to compete. Therefore collaboration is essential if we, in quality and scope, are to be able to meet the challenge," he emphasises.

Kim Guldstrand Larsen has in fact been named to lead the network under ARTIST2 working with Testing and Verification.

The EU is aiming at high-technology networks also in the future. First announcements indicate that the EU's seventh framework programme has also allocated funds to the ARTIST collaboration.

"The goal must be that we 34 universities, in reality, work as if we were one pan-European research centre for embedded software systems," emphasises Kim Guldstrand Larsen.

Read more about ARTIST2 at www.artist-embedded.org



Antennas out for a PhD student

The Danish company SpaceCom A/S is keen to participate in training new researchers at Aalborg University - and also perhaps in employing them afterwards.

The large yellow disc with the brown spots certainly doesn't resemble the kind of antennas we used to fix to the roof in the old days - but that's because these antennas, which are made by SpaceCom A/S, Hobro, are not at all ordinary. They are specially designed to be able to home in on moving objects - mainly ships, but also military vehicles or trucks. Whatever their purpose, they must be in constant and unfailing contact with the communications satellite.

"In the old days we could get away with an HF radio on board the ships and the radio operators knew that there would be periods of black-out where there would be no contact. Today a modern ship handles just as much data communication as a land-based industry," explains Johannes Christensen, Director and General Manager of SpaceCom A/S.

The purpose of the antennas produced by the 41 employees at SpaceCom is to ensure fixed contact with the nearest communications satellite, corresponding to an ISDN modem, in order that the ship can receive and send telephone, fax and data communication. This has to be possible even when the ship is rolling in high seas.

"It is for this reason that we have become specialised in the manufacture of moving trackingantennas. Typically they are equipped with three axles and a number of sensors which can register the way the ship is moving. The reason why we would like to hire a PhD student from CISS is that we would like to see whether we can eliminate one axle by allowing a part of the mechanical movement to be taken over by artificial intelligence. This would have the effect of making the antennas both cheaper and smaller," Johannes Christensen points out.

Unaware of possibilities

At CISS, Roozbeh Izadi-Zamanabadi, Associate Professor, has just found a suitable PhD student for SpaceCom - Seyed Mohsen N. Soltanie. It is Roozbeh Izadi-Zamanabadi who has been in contact with SpaceCom since the company approached CISS about six months ago in connection with another problem.

"We had a meeting where CISS told SpaceCom about the possibility of hiring a PhD student and we agreed that this would be a good way to do it. Bearing in mind the grant and the tax advantages which exist for small and medium sized companies, it is an inexpensive solution. The reason why there aren't more companies hiring a PhD student like SpaceCom is, I believe, based in the fact that they simply don't know that this possibility exists. If they knew how little this costs I am sure that many more small-sized companies would take advantage of it," points out Roozbeh Izadi-Zamanabadi.

A good investment

Johannes Christensen is in complete agreement. "It's a brilliant idea! A company like us would not normally be in a position to have a man just concentrating on research for three years, and apart from enhancing our product we also give a great deal of our knowledge to him so that, in this way, we give something back to CISS," explains Johannes Christensen and continues, "We must of course invest time and energy ourselves in this - but we're quite happy to do that. It is a good scheme."

The SpaceCom director makes no secret of the fact that there is yet another reason for them hiring a PhD student. "We will, without doubt, want to offer the person a job afterwards," says Johannes Christensen.

Important to work together

This new PhD project is not the only collaboration existing between Aalborg University and Space-Com.

"Right now we have two groups of people from the Intelligent Autonomous Systems specialization (IAS), under the Department of Control Engineering who are working with an examination project concerned with solving a problem we have had. Peter Nielsen, SpaceCom's founder and Managing Director, is himself a qualified engineer and for him it is essential that the coming engineers not only possess academic knowledge, but that they are also capable of converting that knowledge into something which can be sold. It is for this reason that he wants his company to work with CISS and with Aalborg University in as many areas as possible," explains Johannes Christensen, who at the same time praises CISS, and especially Roozbeh Izadi-Zamanabadi, for their ability to work closely together with industry.

Software takes over

Roozbeh Izadi-Zamanabadi is a specialist in faulttolerant system design, and his enthusiasm for the subject is apparent when he explains how the sensors, on the one hand, ensure that SpaceCom's antennas point in the right direction but also how, on the other hand, the software can "take over" in the event that a sensor, for some reason, fails. The software can, in fact, simulate that the sensor is working at the same time as it sends a message telling that something is not right. As a result of this the ship is not cut off from the outside world even though an individual component may have failed.

Half of the world's merchant ships are sailing around equipped with an antenna from Hobro, Denmark. No one can see this however as it is encapsulated in a white glass-fibre bubble which carries the name of the company which has produced the signal terminal - the router - which is below deck.

The sailors of today take reliable communications for granted - thanks to a company in Hobro and a little research assistance from CISS.

FACT BOX:

SpaceCom A/S which is located on the outskirts of Hobro, Denmark, was established in 1989 by engineer Peter Nielsen. Today there are 41 people working there including 10 engineers who design and produce tracking antennas for mobile platforms - especially ships.



Fault finding

The testing and validation of embedded software systems is a heavy burden for software companies. Countless hours and large amounts of money are used on carrying out one test after another - with no guarantee that this will ensure a perfect product. An alliance between CISS and IAR Systems aims to rectify this.

On the screen there is complex arrow diagram showing a number of boxes connected with arrows in an ingenious system which a lay person would have difficulty in making head or tail of. But for the trained eye it is a simple and easy to understand overview of a piece of software. The program can even translate the diagram to program code making the software designer's day a good deal easier. In reality, however, it is not until the program is finished that the truly difficult work can begin.

Mathematically impossible

"With this model-based system it has become much easier to design software, but when the program is finished we must begin testing to ensure that it is working as it should - and that it is robust and reliable. It is here where things become very difficult and demanding on resources," explains Ulrik Larsen, PhD Student who, for almost two years, has been working on making this test procedure easier.

It is true that the programs can be tested on the model, but it still has to be done manually and when the program is embedded in a chip, the whole testing procedure starts from the beginning again.

"A myriad of new error-possibilities appear when a piece of software is laid down in a chip. A number of other programs are actually also present on the same chip and the interaction between these explodes the number of possible states which the system is capable of taking on. It is therefore mathematically impossible in many cases to calculate and test all of the system's states," explains Ulrik Larsen.

This is the basic reason why he, together with IAR Systems, is working on automating and simplifying these test procedures.

CISS understands the real world

At IAR Systems in Århus, Denmark, they know that there is a very big market waiting out there - if they can succeed in making the test work less complicated.

"Our customers are very carefully watching the development work we are doing. If we can make testing just 15% easier there will be a lot of money





saved," says Henrik Leerberg, Executive Vice President of IAR Systems A/S. He has worked together with Aalborg University since 1996 and knows many of the people who are at CISS today. It is for this reason that he had no qualms about entering into a collaboration.

"Aalborg University and now CISS have shown, for many years, that they are very good at tailoring their research work to industry. We are able to make use of their efforts in our daily work and our customers are also involved in the process so that there is a constant outlet open to the real world," says Henrik Leerberg.

Attack from the rear

The starting-off point for the project is IAR Systems' software design program - VisualSTATE, and the aim is to create automated test methods in this program.

"Our goal is to automate the testing of the model and to make it easier to test the end product. We can do this partly by using a method called Compositional Backwards Reachability. In ordinary language this means that we go backwards through the system. Instead of starting at the beginning and slavishly going through all the states of the program, we begin at the end. From the desired result we work backwards to find out what is necessary to reach this result. We can cut everything else away. Using this method we can limit the number of states and generate a number of test cases which we can also carry out on the final product," explains Ulrik Larsen.

The art of limiting

"Even this program can have its problems, however. Sometimes the path ramifies to such a degree that it not possible to test all the possibilities. This kind of calculation capacity simply does not exist anywhere in the world - yet. Therefore IAR Systems have to find new methods.

"Even though it certainly doesn't suit the software designers, we are forced to limit the number of ways in which they can express themselves. The more ways in which they can screw a program together, the more difficult it will be to test afterwards. Therefore a lot of our work concerns finding standards. If the designers are prepared to stick to these standards we will, on the other hand, be able to guarantee that the system can be tested automatically. This is the actual object of the whole exercise," says Henrik Leerberg.

FACT BOX:

IAR Systems is one of the world's leading suppliers of tools and expertise in the area of software design for embedded systems. The company has branches in the USA, Japan, the UK, Germany, Sweden and Denmark and employs some 150 people around the world. IAR Systems' products are sold in more than 30 countries. If you are interested in learning more about IAR Systems, please visit **www.iar.com**

Turbo-charged computation

When very large computation capacity is required, several processors must work together. ETI and CISS are trying to find the button to the turbo-charger in this joint project.

"Irrespective of whether you make personal computers, mobile telephones or powerful analytical machines as we do, the main object is to get the hardware, control system, software and the other components to work together as efficiently as possible. In the personal computer and the mobile telephone there is normally only one processor which has to function together with the rest of the system, but we have combined a number of different processors in our machines to obtain the computation capacity necessary, and that makes the interaction somewhat more complex," says Jørgen B. Nielsen, Vice President of R&D at ETI in Nørresundby, Denmark.

Long friendship

To optimise this interaction ETI has entered into a joint-financing agreement with CISS who will pro-

vide a PhD student. This collaboration is a natural progression of ETI's long-time support for the CISS concept. "We were one of the companies who supported the idea when CISS wanted to start as an industry-oriented research centre. At that time we were not in a position to promise that we would be able to contribute anything ourselves, but CISS has shown that it possesses the kind of expertise which we are looking for and we now have found a project we can work together on," says Jørgen B. Nielsen.

Flexible hardware

The joint-project between ETI and CISS has just started and its specific aim is to find a method of integrating the so-called FPGAs (Field Programmable Gate Array) in a flexible way, in the interactions between the various components in ETI's products.

"An FGPA is, in lay language, a piece of flexible hardware. Usually a piece of hardware is designed for one specific purpose, but an FGPA can be reprogrammed from job to job. The advantage in using them is that in many cases they are much faster than software which is why they are called "hardware accelerators", says Associate Professor Peter Koch, who is the supervisor of the project.

Speed versus price

But if speed increases as a result of using FPGAs, the price will also increase. The same job can, as a rule, be done for a tenth of the price using a software solution - but it's slower.

The question of price, however, makes it necessary for us to look for a sensible balance between traditional software solutions and FPGA solutions. We are already using FPGAs in our machines, but we would like to be able to utilise them more effectively. Today they are programmed to carry out a special part of the process. If they are to be reprogrammed to perform some other function then we will, so to speak, have to have them into the workshop. This corresponds to replacing a control system in a personal computer, explains Jørgen B. Nielsen

"The free man"

The idea is that the FPGAs should be capable of changing functions during the process. They are to be considered, let's say, "the free man in midfield" who can lend a hand anywhere it is needed. "In such a system there will always be bottle-necks which will have the effect of slowing down the process. Queues will sometimes occur at different locations in the system when the machine has to analyse a steady stream of data. This is where the FPGA should be able to hop in and help in minimizing the problem," explains Peter Koch.

The extra expenditure incurred in using these hardware accelerators will be more than covered, if we are successful in developing new advanced methods for doing "on the fly" modifications.

Necessary to invent tools

There are no tools existing today which can help us to reprogram an FPGA on the fly. In fact there are no tools in existence which can give us even a faint idea of whether this can be done at all. For this reason we have no expectations of having an operational machine when the project is over. If we are lucky we will have some tools to help us in designing our machines so that a solution may be found in the future," says Jørgen B. Nielsen.

FACT BOX:

ETI was established in 1985 and develops advanced technology for analysing and trouble-shooting communication systems. The company today has branches in the USA, the UK and Denmark. If you are interested in learning more about ETI, please visit **www.etiglobal.net**





Researchers have taken the first steps in designing software which should be able to allow groups of robots to work together.

For most of us robots are either something you see in a science-fiction film or they are industrial robots which are used to assemble cars and the like. We also know that the vacuum cleaner or lawn-mower which drives itself is a type of robot. Researchers at CISS are, however, already busy trying to find a way to transfer human social characteristics to software. Henrik Schiøler, Deputy Director who is also an associate professor in the Process Control Department explains, "Imagine that you have a group of mobile robots - it could be a group of robots which monitors different departments in a supermarket. The idea is that our robots will not only be able to navigate around the room - they will also be capable of exchanging information with each other."

"In such a supermarket there will be a certain number of charging stations or locations where the robots can collect batteries. When a robot needs to be charged and has to leave the area for which it is responsible, the other robots working in the area must know, so that they can take over the monitoring of this area. In addition it is desirable if the robot closest to the charging station were capable of taking newly charged batteries to a robot which is located further away in the supermarket - or that the batteries themselves can wander from robot to robot until they get to the robot which needs recharging," explains Henrik Schiøler.

"We are talking about a form of population dynamics which we also know from simple societies. We can, therefore, get inspiration from actual biological populations and game theories. To be able to provide each other with energy - in this case batteries - is essential for the survival of the species. It is for this reason that we believe that it is a basic necessity that we are able to inject the right "instinct" so that each individual robot is able to function in a way which is of benefit for the group as a whole. After this, we can begin to assign more tasks to the group," Henrik Schiøler points out.

At the moment a lot of what Henrik Schiøler is talking about is mostly theory, but on 1 October 2004 PhD Student Trung dong Ngo joined CISS. Trung comes from the Mærsk McKinney Møller Institute for Production Technology at the University of Southern Denmark where he has been working with modular robotics. At CISS he will be continuing his project by building up a robot population. "We are still at the basic research stage, but I am convinced that the work Trung is doing will be of benefit to industry when groups of robots, maybe in just a few years, will be able to serve office staff," emphasises Henrik Schiøler.





Unexpected spin-off

Research at CISS into real-time systems has resulted in an unexpected spin-off. The methods of computation which CISS has developed have proved to be ideal for planning complex working procedures.

"We have discovered that the algorithms and data structures we have developed to analyse and test real-time systems are also particularly well suited for computing optimal procedures in connection with major processes," says Jacob Illum. Since August 2003, he has been working on a faculty grant, examining the possibilities of developing this surprising extra bonus.

From code to steel

Scheduling, as this process is called, mainly concerns computing how a series of procedures should be carried out in order to achieve the most effective result. This applies both to data systems and to real life situations.

"We are, for example, working together with a steel rolling mill in Gent, Belgium. They want to optimise their procedures connected with the moving around of the raw iron-ore. This is a complicated process and we are trying to compute how it can be done using as few resources as possible. The methods are no different than when we have to calculate how we get an embedded system to work with the lowest possible use of power and storage space," says Jacob Illum.

Alternative and better

This type of scheduling is a discipline which is normally seen among researchers who are working with artificial intelligence and operational research. And the computational methods which Jacob Illum is using also differ radically from traditional scheduling methods.

"We do it in a very different way, but it has proved to be more effective in several areas than traditional methods. In some areas our method is not so suitable, but I am working on improving these areas by integrating some of the traditional methods in our analyses," says Jacob Illum.

There is money in it ...

Professor Kim Guldstrand Larsen leads the project and he envisages broad perspectives for these planning methods in the future.

"The ability to be able to make complex working procedures more effective is in great demand. We know this from our daily working life when we have to start on a major project; where should we begin and where should we end and in which order should we carry out the various tasks? When should a certain activity be started up? Answers to these questions are very much sought after," says Kim Guldstrand Larsen who is in no doubt that there will be a commercial spin-off connected with Jacob Illum's work.

"The people who are working with these things must, of course, decide how the results should be managed, but I could easily imagine it leading to a patent in the end," says Kim Guldstrand Larsen.

Vaccine for your mobile phone

Virus and hacker attacks are rife - and not only via the computer. The mobile phone and other electronic devices are also in the danger zone. The Danish telecommunications company TDC, in collaboration with CISS, intend to find a cure for this.

"The Umbrella project". It sounds more like a star wars project, or perhaps the title of a detective novel, but in reality this project is about three students from Aalborg University and their attempt to protect us from the dangers of the internet.

Electronic influenza

"Communication possibilities between electronic devices via the internet are increasing rapidly and with this comes the risk of virus and hacker attacks. Recently there was an example of a virus which had been designed for the Bluetooth technology in a special type of mobile phone. The result was that if two telephones were in the vicinity of each other and were switched-on they could infect each other - just as influenza is contagious between humans," explains Michel Thrysøe who is one of the students. The least that can happen with this type of attack is that the telephone will become defect, but a worst case scenario is that intruders would be able to gain access to all the information stored on the telephone including address book, diary, e-mails and text messages.

Can save lives

This was an obvious research project for TDC to join in with and they were not slow in offering joint-financing when an employee heard about this special project being carried out by three students as part of their computer science studies. Primarily, though, it is not mobile telephones, but a futuristic project concerning internet-based alarm boxes which will be benefiting from the three students' work.

"Internet-based alarm systems require an internet link-up with several channels so that the alarm can have its own separate channel. This is something we are working with, but in order to be completely sure that no one can gain access to our systems through the alarm boxes or that anyone could deactivate the alarm boxes from the outside, we have joined "The Umbrella Project". Operational security in this area can be of crucial life-or-death significance so we must create as many obstacles as necessary to ensure that no breach is possible," says Frank Larsen, a TDC Systems Consultant.

Guards at the door - and isolation

The idea behind "The Umbrella Project" can be described in two parts. On the one hand, an electronic device must be able to download software from an approved supplier. This means that the supplier must be able to identify himself by means of an electronic signature. On the other hand, the downloaded software must be isolated on entering the device.

"Try to imagine for a moment that the "I Love You" virus or other vira which have previously caused havoc in computers around the world, could not gain access to the mail system or the address book - then they would be unable to proliferate and the destruction would be limited," says Kristian Sørensen who is one of the three students behind the project. As far as the mobile phone is concerned it means that, for example, downloaded games or the like cannot be used as a "backdoor" for hackers.

Reversed logic

In order to achieve this, the three students begin, so to speak, at the end.

"Today, most systems specify what the individual program or the user may access. We begin by defining what it is they may *not* have access to. In this way we are able to create a security shield around the program and at the same time save ourselves a great deal of working time. The number of "forbidden areas" is in fact much smaller than the opposite," says Kristian Sørensen.

Simple and useful

It sounds simple, and one of the main requirements in this has been simplicity, since these three students started out on their thesis project.

"Security systems do already exist but they are very big and complex. We have been working with this for two years now and we don't fully understand them. As a result of this they are totally unsuitable for embedded software where calculation capacity and resources are naturally limited," says Søren Nøhr, the last of the three inventors.

"If this is to be widely used we have to make something simple which can also operate on very small systems. This has been our goal from the start," says Søren Nøhr.

Broad perspectives

It does also seem that these three students have struck gold. There has been a lot of interest from companies all over the world, but right now the main concern is to secure TDC's future alarm boxes. Then we can begin to examine how these security ideas can otherwise be implemented.

"If the ideas lead us in the right direction, as it seems they will, there is, of course, the possibility of applying for a commercial patent and we will be following the design work very closely. The best thing, of course, would be if it becomes a public system which can secure everybody's electronic devices and I believe that there are great possibilities here," says Frank Larsen from TDC.

FACT BOX:

"The Umbrella Project" is being carried out under the auspices of the so-called OS Lab at CISS and has, from the beginning, been supervised by Emmanuel Fleury, Assistant Professor. The OS Lab has previously worked on successful joint-projects with such companies as Simrad and Aeromark where the emphasis was on testing and research concerning possibilities in the area of new operative systems. If you are interested in learning more about "The Umbrella Project", please visit: **umbrella.sourceforge.net**

Michel Thrysøe, Kristian Sørensen

and Søren Nøhr Christensen, Master's Students at CISS

First we take Manhattan...

The Umbrella Project has attracted a lot of attention both domestically and abroad. The three students behind the project have just returned home after having attended a workshop in the USA where they met with some really important players involved in the area of CE devices.

Sony, Phillips, Panasonic, IBM and Samsung. These were just some of the names represented when the three students, Michel Thrysøe, Kristian Sørensen and Søren Nøhr, together with their supervisor Emmanuel Fleury, travelled to Princeton, New Jersey to participate in a meeting with a security working-group under the auspices of the Consumer Electronics Linux Forum. At the meeting the three students were invited to present their Umbrella Project and discuss security with the companies involved.

"When we began the project we looked for different companies producing Linux-based products who we would be able to exchange ideas with. Panasonic was one of the companies which contacted us and they have been on our mailing list ever since so we have had continuous contact. However, it has always been quite informal so we were quite surprised when they suddenly invited us to the workshop," says Søren Nøhr.

For the record

CISS consented to pay for the trip and so we were on our way to New York and then on a little southward to New Jersey.

"It was quite different, suddenly, to be walking the streets of New York on a Monday morning when we would normally be working in our office surrounded by coke bottles and pizza boxes. When we arrived in Princeton, everything was nice, and very informal. There were around 15 people present in a conference room and business cards were eagerly exchanged," says Kristian Sørensen, while emphasising, at the same time, that the relaxed atmosphere in no way impaired the air of professionalism. "This was a very skilled group of people who represented an extremely broad range of products, but who listened to what we had to say. Our input can be read in the minutes of the meeting," says Kristian Sørensen.

Collaboration and job offers

The workshop has meant that the hitherto informal contact we have had with Panasonic from the beginning of 2005 will now be more formalised in the form of a contract which will have a major influence on the future working relationship.

"When we have received the paperwork in connection with matters of confidentiality etc. they will be able to tell us much more about their weaknesses and the types of problems they actually have with security. Once we know this we will be better equipped to ensure that we are working on the right problems," says Søren Nøhr.

Apart from this the trip to the USA has resulted in the three students being invited to go to Tokyo to work during the summer, but as yet no one knows for sure what the future will bring. But one thing is for sure - there are many possibilities ahead.

A pat on the shoulder

"We do not have any well defined goals on the horizon. For the moment it is enough to get a pat on the shoulder and be told that we are great. We now have to consider the various possibilities, but right now we have our hands full developing the final part of the project and making a prototype for TDC," says Michel Thrysøe.

Firstly though, a paper has to be written to establish the ownership rights in connection with the work already done on the Umbrella Project and even though there is no well-defined goal there is no doubt about what would be the ultimate recognition for the three students.

"We hardly dare think the thought, but the greatest thing for us would definitely be if our work, in one or another way, could become an integrated part of Linux. This would be the optimal recognition in our world - and it would look really good on a CV," says Søren Nøhr, with a big smile.





Explorers in design

A guidebook to an infinite universe. That's what Yannick Le Moullec is trying to create through his research into design solutions for embedded systems.

"Design space exploration" is the name of the work carried out by Yannick Le Moullec, Post Doc. In layman's language it means that he is researching the possibilities in different designs for embedded software.

"I try to give good advice, so to speak, concerning the types of designs which are most suitable for solving different types of problems. In principle there are innumerable design possibilities for every individual task and my job is to narrow it down," says Yannick Le Moullec.

Based on experience

For this purpose Yannick Le Moullec has designed a program called Design Trotter which, by means of experience, can provide suggestions based on input and guidelines.

"The idea is that the designer tells the program what he has to do, how much memory it can take up, how much time it is allowed to take, how much power can be used etc. and then the program will provide suggestions for various design solutions," explains Yannick Le Moullec.

Applications and effectiveness

The way you design your hardware has a significant influence on the properties an embedded system has. For this reason it is important to find the design solution which is closest to the required properties. "Design Trotter operates in two steps. First the program is given a specification with various types of input and calculates values for different properties. In this way we can see whether the design has a "high score" when compared to the required properties. Then the program goes ahead with scheduling. Simply put, this means that the program determines how efficiently a task is carried out using that design. It can well be that the task's functionality is carried out perfectly, but if it requires large amounts of power and memory it will not be the perfect solution," says Yannick Le Moullec.

Latest news

In order for Design Trotter to be capable of coming up with the best possible solutions all the time, Yannick Le Moullec must constantly keep himself updated as to what is going on in the world of embedded systems.

"Obviously, if I see an exciting new architecture, I have to include it in my program and I have to discover exactly what characteristics this particular architecture is made of. It could well be that it is exactly the design solution we need for the next task," says Yannick Le Moullec.

FACT BOX:

If you would like to know more about Yannick Le Moullec's work, please visit **www.cs.aau.dk/~moullec**

Keeping time

As a rule, time passes in discrete steps in digital devices, according to clock cycles. However, to simplify the analysis of such systems abstractions it is particularly useful to disregard the exact granularity or cycle length by considering time as a continuous phenomenon. In recent years, however, more and more systems have begun to define time as a flowing concept - this is called "continuous time". CISS is among the world's elite in this area.

"When you work with time as a "flowing" concept you have many advantages, but there are also some problems where mathematical solutions must be found. You will, for example, very quickly run into an "infinity problem" when time is not divided up into bites and our algorithms have to allow for this," says Gerd Behrmann, Associate Professor, who is one of Denmark's leading researchers in the area of testing and verification of socalled real-time systems.



When time is of the essence

One of the things about real-time systems is that it is not enough for things to happen in the correct order.

The time which elapses between the various actions is also of importance - exactly like an airbag in a car. It is not good enough if the airbag takes half an hour to be released after the car has crashed - this must happen in a matter of milliseconds. This extra requirement in the systems makes them somewhat more complex than the traditional ones - the so-called "discrete software systems". As a result of this it has been necessary for some new thinking in order to be able to analyse and test these system types effectively.

The relevance of the interval

With such complex systems we quickly run into the problem that the system can take in an infinite number of possible states - a so-called "state space explosion"- which makes it impossible to analyse the system state unless we have an ingenious answer to the time problem. We have therefore constructed the algorithms so that time is only a factor when something interesting is happening in the system," explains Gerd Behrmann.

"Time is divided into for example milliseconds, in traditional testing tools, so if nothing happens in the system for a period of 100 milliseconds it will still represent 100 different states because the time has changed. In our system, on the other hand, time is only relevant, so to speak, when something else is happening," says Gerd Behrmann.

Early testing

Together with researchers from Uppsala University and Aalborg University, Gerd Behrmann has helped to design a tool called UPPAAL which can be used to locate errors in real-time systems even before the final software is designed.

"This can be used to create models of real-time systems which can then be analysed before the final design stage. This is done in exactly the same way as the engineers do when they create a diagram of a bridge so that they can analyse the model from every angle, before they actually start building the bridge itself," explains Gerd Behrmann.

In October Gerd Behrmann was awarded the Spar Nord Fund's Research Prize in the sum of DKK 250,000 in recognition of his work in connection with the designing of verification tools for real-time systems in embedded software.



No room for error

With the new definition of time, Gerd Behrmann and his colleagues have managed to push the always present State Space Explosion a little further out into the future.

"We have not solved the problem as it is actually an insurmountable one - but we have given ourselves a little time, and every time we can postpone the "catastrophe" in this way we can use the method in more systems," says Gerd Behrmann.

There is a big demand for tools which can test real-time systems in this way - especially in embedded systems. An error in an embedded system is in fact both expensive, bad for the reputation and can be dangerous.

"We have gradually learned to accept that there are software errors in our personal computers and that we can get regular updates, but it is not the same for embedded systems in cars, planes or hospital equipment. Here they must work the first time. This is why it is so important to be able to analyse the system both before, during and after developing the final product.

Model versus reality

Behrmann's colleague Brian Nielsen and PhD student Marius Mikucionis are responsible for the development of methods for testing the final product.

"We have to test to see that the product has the qualities it should have, so to speak - and that the product corresponds to our expectations based on what we learned from the model.

It can well be that it runs perfectly as a model but we have to be certain that it actually functions in reality," says Brian Nielsen.

To do this he uses test sequences from the model and runs them on the end-product.

"We select a broad range of test sequences which, as far as possible, represent all the abilities and timings of the system. We also check that the results of the tests done on the end-product correspond to the results of the tests done on the model. The challenge here lies in finding a suitable number of tests and in adapting the test sequences to the actual hardware. This can vary from company to company and from product to product so we must constantly combine the physical world with the virtual reality of the model," says Brian Nielsen.

No more slavery

And, preferably, everything should be able to function automatically. It is not particularly smart if you have to feed the end-product manually with input from the model tests to see what comes out of the other end.

"This is actually, to a great extent, what happens today in fact. Endless hours, resources and many student assistants are used in the manual testing of products. We can offer to do this automatically so that the system can itself run the one test sequence after the other and can itself report the existence of any errors, " says Brian Nielsen.

FACT BOX:

If you would like to know more about the work being done with real-time systems and in particular UPPAAL, please visit **www.uppaal.com**

www.cs.aau.dk/~marius/tuppaal/

CISS at the lectern

Alternative courses based on the employees' daily work with follow-ups when necessary. This is the latest offer from CISS to Danish IT companies.

We have all experienced it. The course was exciting and inspirational, but after a while all the good intentions are forgotten. Everyday problems can't quite be fitted into the fine boxes and models which otherwise seemed so practical on the course. CISS will rectify this with its offer of more realistic and long-term learning processes in connection with embedded software design.

Based on everyday job requirements

We want to create courses and longer-term coaching which will be based on specific projects related to a company's everyday work instead of using pre-determined examples of ideal situations," says Arne Skou, Associate Professor, CISS.

Together with a couple of companies and colleagues from the Department of Computer Science he is designing the content for a goal-oriented learning process in the design of embedded software. The course is based on the so-called "workbased learning" model where activities are based on actual work being carried out in the company. This model has become more and more popular in universities throughout the world over the last ten years and it is regularly used in connection with Aalborg University's further education activities.

LAR visualSTATE

anross kernel

Where does it hurt?

tmega 16

"We have asked ourselves why there are not more companies making use of the excellent and effective models for software design to be found in the many available textbooks - not least the ones written by our own colleagues at Aalborg University. We have therefore, together with them, entered into a collaboration with a number of companies where we, among other things, monitor and guide their daily work. In this way we can keep the company on course and at the same time learn about the obstacles they meet when they introduce the new work methods - and we get important input for our research into embedded software into the bargain," says Arne Skou.

We try again

One of the companies currently working regularly with CISS is Siemens Mobile Phones Development in Nørresundby, Denmark.

"We have, for a long time and on several occasions, tried to implement new work methods, but each time the ordinary daily considerations have distracted us from this after a while. New skills have simply disappeared because people have not found it possible to integrate new knowledge into their daily work," says Svend Holme Sørensen, Dept. Manager, Siemens.

"Now we are trying, together with CISS, to retain what has been learned and to adapt this, where necessary, until new routines are in place," says Svend Holme Sørensen.

Find reality

He is in no doubt that the new work methods will be of benefit to the company when they are implemented, but there is a lot of work to be done in order to adapt these methods to the individual company and to its specific realities.

"Surprisingly often, when university people write text books about these methods, they use the same examples. This is, of course, fine so that their results and discoveries can be compared, but it is not so good when these results have to be transferred to the actual situations in the companies. It is this process we are working on now," says Svend Holme Sørensen

Regular visits

In practical terms, the course is based on concrete projects which people are working with in the course of their jobs. After this there are follow-up visits every 14 days or so, to deal with new problems.

"We are trying this at the moment in connection with two concrete projects where there are six people involved. If this is a success I would expect that we would use this training programme in connection with other projects," says Svend Holme Sørensen.

Old friends

The joint-project between Siemens and CISS is built on an old friendship.

"We have previously used both Aalborg University and CISS as working partners in various contexts, with great success, and some of the people we have worked with earlier are now at CISS. It was quite natural therefore that we should try this type of alliance and up to now is seems to be working really well. We are just now in the phase where it is important to be insistent and to make it work and here it clearly helps with a regular exchange of knowledge," says Svend Holme Sørensen.

New friends

At CISS they are convinced that courses of this type will be a success - also with new working partners.

"We have a specific professional competence and many of the people at CISS have experience in holding courses from the university's wellestablished and efficient course centre. These two things combined mean that we can offer training programmes which are based on very specific projects where there is a concrete goal. I am sure that many companies will be interested in this to run parallel with the more general forms of further education they offer their employees," says Arne Skou.

FACT BOX:

If you are interested in learning more about CISS courses, please visit <u>www.ciss.dk</u> Further information about work-based learning can be viewed at <u>http://elite.aau.dk/wbl/</u>



A network of knowledge

CISS is working with a number of companies in an effort to improve the companies' software design. The whole process, from concept to end-product, is being examined very thoroughly.

How do we manage the work itself? How can we ensure quality in regard to processing and the product itself? What are we good at and what should be better? Which tools should we use? The answers to these questions can be decisive factors having an effect on whether a company experiences success or failure in an increasingly competitive software design market. It is for this reason that CISS, together with a number of Danish companies are trying to find new answers to the old questions.



Jørgen Biegel, Project Co-ordinator, Tekkva Consult

From A to Z

"Generally speaking I would say that we are trying to develop and improve the processes which have to be gone through when designing software. We are looking at everything from planning over project management to the actual tools which the design engineer is using in his daily work," says Arne Skou, Project Manager at CISS.

He has been working on the project which is named Prosoft, together with 12 private companies and the Herning Institute of Business Administration and Technology since the beginning of 2004. It is a project which is divided into six parts.

Different goals

"Some of the parts should result in an actual piece of software or a clear and manageable manual for software designers whereas other parts are more concerned with testing new things and gathering knowledge from experiences. This will form a knowledge base that companies can use in the future. When the project finishes at the end of 2005 we should have both some actual tools and an amount of knowledge which we can pass on," says Jørgen Biegel, Project Co-ordinator.

The project is being financed partly with a grant in connection with "The Jutland-Funen IT Drive" and partly by the companies involved who will be providing people for a fixed number of hours.

A good investment

"The companies pay in hours, so to speak, but in return, of course, the employees who work on the project have the possibility of gaining a great deal of knowledge and completely new experience. And if you consider how expensive it is to send people on courses, and the like, I am sure that the companies get a very good return on the hours invested;" says Jørgen Biegel.

In practice the project runs on the basis of a fiveweekly meeting between the people involved in the various sub-projects to share experiences from the different tasks they have been working on in the interim period.

"We look at things from the point of view of the design engineer. How can we make his work easier and better? It can well be that the people who meet up have high positions in the companies, but most of them are, primarily, designers and it is as designers that they participate in the Prosoft project," says Jørgen Biegel.

FACT BOX:

If you would like to know more about the individual projects of the Prosoft collaboration, or those involved, please go to **www.komit.tekkva.dk**



Call your coffee-machine

The remotely-controlled home - or Home Automation as it is also called - is no longer pure science fiction. CISS is engaged in a project which will ensure that electrical domestic devices of the future will speak the same language.

Imagine that all the electrical articles in the home - including the coffee-machine, the tumble dryer and even the under-floor heating in the bathroom or the lights in the lounge - could be remotely controlled, either by using the same remote control unit you use for your TV, video and DVD player or by using the family computer a mobile telephone with Bluetooth.

This is already possible, from a purely technical point of view. But the further development of Home Automation is being hindered by an old and familiar problem: standards - or, more correctly, the lack of a common standard. The technologies are not speaking the same language. This makes it as good as impossible for the average family to install Home Automation products themselves.

However - a group of companies, together with CISS, is now working on finding a solution to this problem.

Open standard with own logo

"With Jørn Eskildsen, Amfitech, as leader we have set up OHAP, Open Home Automation Project, which is a non-profit organisation. OHAP has suggested - and defined the principles for - an open standard for automation in the home. This standard will, in principle, make it possible to go down to the DIY centre and buy products - for example a lamp - and if it has the OHAP logo on it you will know that it can communicate with the automation you already have in your house. Apart from this it must be simple to install. In fact we have already, in a research fellowship project, developed a prototype based on the OHAP group's model." Henrik Schiøler, Deputy Director at CISS who is also an associate professor in the Department of Control Engineering warms quickly to his subject when he talks about Home Automation. For him and for the other members of OHAP it is important that automation in the home is not only something to be used in the homes of the future, but that they should also be easy to install in existing homes.

Hidden from thieves

"Home Automation with an open standard, however, is not without its problems. Imagine that you have installed surveillance in your home - and that your neighbour can get into it via the open standard. Even worse would be a situation where a burglar could use your surveillance system to scan your home for valuables, before he breaks in. It is not only this kind of security, but also data security which has to be considered in new systems like this," Henrik Schiøler points out.

Surveillance is, in fact, an area in which Henrik Schiøler and CISS have a special interest as CISS, together with Zealand Care, has applied for funds from the Jutland and Funen IT drive.

They want to experiment in using Home Automation help old or sick people to be able to remain in their own homes. It is here where surveillance and call-up systems in the event of emergencies are important elements.

"Naturally, home care must also be based on a standard which makes it possible to couple-up new aids to the system - as in the OHAP standard,"

The world as a giant server

Imagine if computer capacity were something you could have delivered as you need it. If a global network were able to provide you with exactly the amount of computational power you needed and you only needed to pay for what you used. This is, in fact, just around the corner.

"In days gone by you had to buy a generator if you wanted electricity. Of course it had to be big enough to cope with your peak-load periods, but the rest of the time it would just stand there producing what was necessary - not being optimally used. Today we have the electricity networks which make sure we get exactly the amount of electricity we need and we pay for what we use. We are trying to create something similar for computer capacity," says Josva Kleist, Associate Professor at the Department of Computer Science.

Money and new possibilities

The creation of a global network for computer capacity would have many advantages - both for companies and researchers.

"Today, companies are forced to invest in a super-computer, or a so-called cluster, if they have a need for a very large capacity. If, instead of this, they were able to send the job out on a network via an ordinary computer and pay for the capacity they use - a great deal of money would be saved," says Josva Kleist.

But also research and development of embedded systems can benefit greatly from a network for computer capacity. This is where CISS comes into the picture.

"Embedded systems have today very limited resources, but if they could collect capacity from a network they could maybe carry out many new and much larger tasks," says Josva Kleist.

Take me to the moon

They were, in fact, already using this technology back when the Americans landed on the moon. The computer in the space module which actually landed on the moon was, naturally, relatively small because of the limited power resources so all the major computations were carried out on Earth and transmitted up to the astronauts.



"In the same way you could imagine embedded systems in all sorts of electronic apparatus being able to download computational power from the network so that they would be able to carry out much more complicated computations than they can today," says Josva Kleist.

Scandinavian network

From a technical point of view there is nothing standing in the way of this and already now researchers are benefiting greatly from the so-called Grid technology.

"In Scandinavia we have a network where there are 4-5000 computers linked up. This is used by researchers when they have heavy computations to carry out - for instance, testing and verification of embedded systems which is one of the core areas for CISS. Computations are carried out on super-computers or clusters spread around the world, but the individual researcher just uses his ordinary computer without worrying about where the computations have actually been carried out," says Josva Kleist.

Also for the general public

In the long term Josva Kleist expects Grid technology to be part of everyone's daily life, and there would be many advantages for the individual private user.

"Today many of us have a computer which is capable of much more than we actually use it for. If we could download computational power as we can energy - when we need it - we would be able to save a lot of money. We would not have to go out and invest in a new, bigger computer each time technology takes a step forward and the old one can no longer cope with the load in the new programs and the new tasks which the computer has to undertake," says Josva Kleist.

Safety first

There are, however, still some major challenges which have to be overcome before Grid networks are useable and attractive for the individual private user. First and foremost comes the question of security.

"We must be sure that nobody can spy on what we do on our computers. A job sent out on the network will possibly be undertaken by somebody else's computer and we need to be sure that he cannot see the data. In many areas there will have to be much more security than we have on the telephone network where we trust that the telephone companies do not monitor us or let anyone else do it. We simply have to make sure that it is impossible to do this. This is probably the biggest challenge we are faced with before a global network of computer capacity can become a reality," says Josva Kleist.

FACT BOX:

If you would like to know more about the work going on in connection with the creation of a global network for computer capacity, please visit the following sites

www.gridforum.dk www.dcgc.dk www.cs.aau.dk/~kleist www.nordugrid.dk





A helping hand for inventors

Inventors and small companies in North Jutland are now finding it easier to bring their ideas to fruition. Behind this initiative is Mindwork together with, among others, CISS.

"The mobile telephone fairytale in North Jutland shows that to survive we must have good ideas, and be capable of developing them, so that they can come into production. Good ideas are not only to be found in a research environment at Aalborg University. They also emerge in the companies themselves, from small craftsmen and other people with inventive minds. The better we are at transforming ideas into something concrete, the better chance we have of being able to serve each other and thus create growth in North Jutland." These are the words of John Robert Andersen, Man-

aging Director, Mindwork. He is convinced that a snowball effect could be started by combining those whose speciality is research and documentation - CISS among others - with those who have the ideas and then make contact with the companies which have the possibilities and resources to put the ideas into production – and he has a plan...

Test house to show inventions

"We want to build a test house and we want to establish test environments in companies which other companies and citizens can use when they want to try out their ideas," John Robert Andersen points out.

He explains, "At the present time we are seeking financial backing to enable us to build a test house where we can demonstrate what automation in the home can mean to us all in terms of our everyday lives. CISS are heavily involved in this project. The idea is to show different examples of inventions and solutions. For example, it could be a system which measures grass pollen and dust and is capable of cleaning the air in a room so that people with allergies can be spared some discomfort. Another example could be a meter whose display can indicate, in cash terms, how much could be saved by using the washing machine at night."

Development network – on the net

North Jutland Innovation Forum has recently granted DKK 110,000 to a pilot study of Mindwork's other large-scale project, the establishment of test environments in North Jutland. It is this project that is designed to benefit the region's inventors, both those who are at the universities, in the companies and at home in their garage. For a start a portal will be set up on the internet - a virtual notice board - where inventors can look for companies who can make prototypes, test-people to try out an invention, researchers to document the effects of their invention etc.

In this way the ideas should be able to grow out of the laboratories, workshops and garages and find their way into production - thus creating jobs and activity in the region.

Behind this project is Technology Network, established by Mindwork, in which CISS is also engaged.

FACT BOX:

Mindwork is a North Jutland network and commercial service organisation started in 2000 by Aalborg University, NOVI, the County Council of North Jutland and Aalborg Municipal Council together with 27 IT companies around Aalborg. Mindwork now has more than 40 members. Read more about Mindwork at

www.mindwork.dk

An investment in product development

Economic support for CISS is shared by Aalborg Municipal Council and the County Council of North Jutland. The money is expected to result in increased development and the centre is closely monitored.

"We are experiencing radical change in our commercial and industrial environment here in North Jutland and the way we will survive will be through product development and processing. This is why the County Council and ourselves are in agreement concerning the importance of supporting our regional university when they enter into joint projects with companies in the region. The DKK 6 million we have allocated to CISS - 4 million from Aalborg Municipal Council, 1 million from Aalborg Commercial Council and 1 million from the Region Aalborg Cooperation - is an investment in the future and we are keeping a sharp eye on our investment," explains Vibeke Lei Stoustrup, Project Manager, Aalborg Municipal Council. She continues, "For Aalborg Municipal Council it is not so important where in the region the company benefiting from collaborating with CISS is located. For instance, many people commute into the Aalborg area everyday while others commute out of Aalborg. Therefore good results will have a positive effect over a much wider area than that municipal area in which an individual company is located.

Trade promotion officers have the contacts

Vibeke Lei Stoustrup hopes that CISS will be successful in making contact with a wide range of companies which normally do not work together with Aalborg University and the council is not just looking passively on. "In the late summer of 2004 we invited CISS to a meeting with the trade promotion officers of the Region Aalborg Cooperation which is a commercial joint project between 12 municipalities in the Limfjord region. It is these trade promotion officers who are out in the individual municipalities and who are in contact with the companies. At the meeting CISS presented, among other things, the attractive 150% scheme where companies can "hire" a PhD student and deduct 150% of the expense. It was a very positive meeting where the commercial managers listened intently," tells Vibeke Lei Stoustrup who is looking forward to seeing to what extent the trade promotion officers will be able to cultivate new contacts between CISS and companies in their areas.

CISS strengthens the partnership

"It is also my impression that the many engaging seminars held by CISS - which are attended by companies from all over the region - are contributing to the establishment of new alliances which are of benefit to the companies," Vibeke Lei Stoustrup points out and continues, "But, seen in a wider perspective, it is also positive that CISS - through the Jutland-Funen IT drive - is involved in making contact with other universities, for example ISIS residing at Århus University. It is a reinforcement for the companies in the region that they - through CISS - can call on skills offered by the other Universities"

"In global terms we are not so big, so it is important for us to have partnerships with others and to cultivate relationships if we are to make it to the finishing line. It is therefore that the Jutland-Funen IT drive is so important," Vibeke Lei Stoustrup emphasises.

Vibeke Lei Stoustrup, Project Manager, Aalborg Municipal Council.

