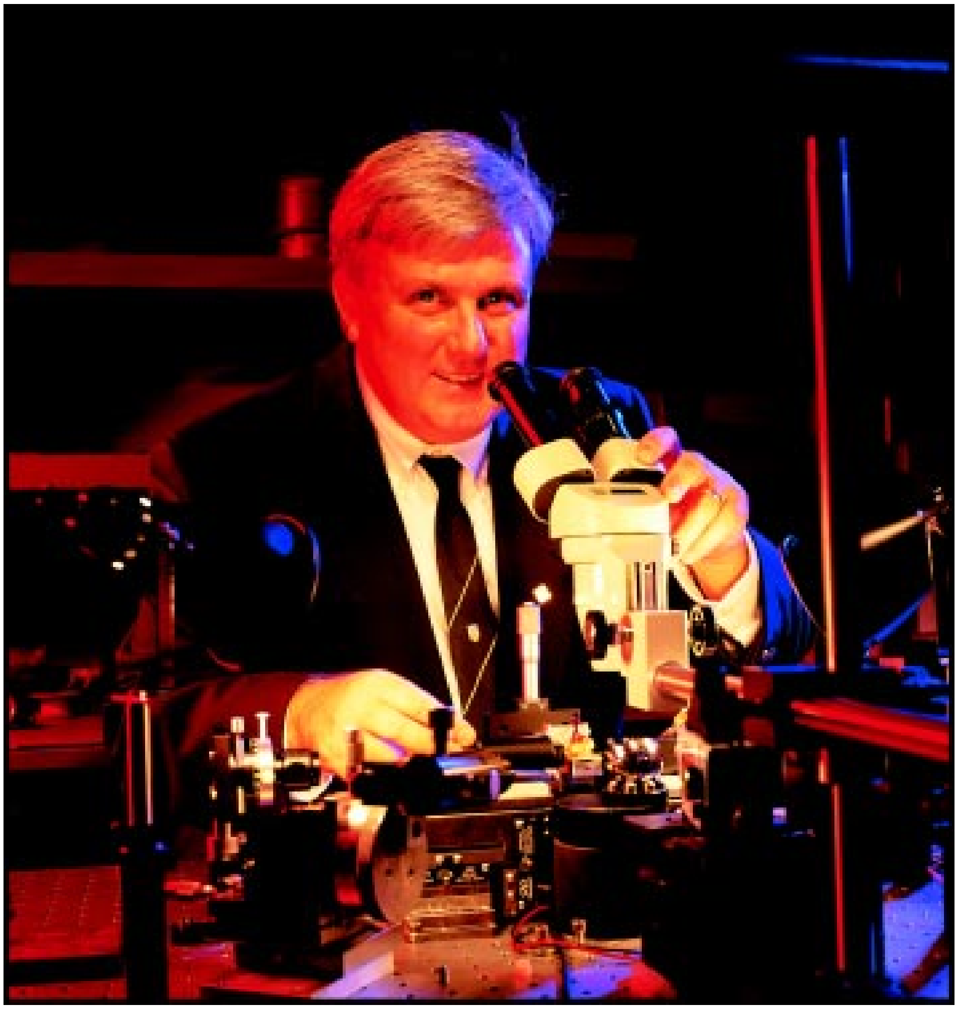
CENTRE FOR INTEGRATED COMPUTER SYSTEMS RESEARCH

CICSR FOCUS

THE UNIVERSITY OF BRITISH COLUMBIA

Revolutionizing How Power is Measured and Managed

The voltage measurement technology invented by Nick Jaeger fuelled a merger with industry giant Honeywell.



Director of the Centre of Advanced Technology in Microelectronics, Nick Jaeger is interested in broadly-based interdisciplinary work—and the resulting partnerships.

Today, when we flick on a light switch, zap our coffee in the microwave, or power up our computer, we take electric power for granted. Most of the systems that monitor and measure the power we use have been around for half a century or more. However, as the need for dependable power increases, it is clearly time for a change.

Deregulation of the US power industry is not only facilitating that change, it is fuelling demand for the technology developed by Nick Jaeger and industry partner NxtPhase Corp.

Integrated-optic sensor technology

CICSR member, professor of Electrical and Computer Engineering, and ASI Fellow Nick Jaeger has been working on integrated-optic sensor technology for over a decade. In collaboration with Dr. David Green of Carmanah Research Ltd., and with the financial support of the BC Advanced Systems Institute (ASI), the Science Council of BC, and the NRC, he developed a technology capable of monitoring the quality of insulation inside high-voltage equipment.

This successful project led to the creation of UBC spin-off Carmanah Engineering, aimed at marketing the technology. With this project completed, they soon convinced the power industry that equipment monitoring represented a fraction of the market for optical technology relative to the need for

continued on page 2

CICSR Spring 2000 Vol. 11, No. 1

CICSR
Director's Corner

From cutting fish with fuzzy logic to computing with DNA, this issue of FOCUS has a fascinating editorial line up. First, we are pleased to announce that Victor Leung has been appointed the TELUS Mobility Research Chair as part of an exciting new partnership with TELUS and UBC. Victor's research on wireless networks is featured in this issue.

We also feature Clarence de Silva who holds the position as NSERC Research Chair in Industrial Automation. Funding from industry partners such as BC Packers, BC Hydro, ASI, and the Garfield Weston Foundation has spawned some of Clarence's most exciting research—such as his automated fish cutting technology.

CICSR is pleased to welcome Anne Condon to our research team. Anne comes to us from the University of Wisconsin, where her work in computational complexity theory helped to pioneer research on DNA computing.

We also look at Nick Jaeger's work on power management systems that led to the creation of NxtPhase Corp., an exciting merger between former UBC spin-off Carmanah Engineering and industry giant Honeywell.

Uri Ascher and his collaborative work in electromagnetic imaging, with Doug Oldenburg of the department of Ocean and Earth Sciences, demonstrates the importance of applied mathematics to real-life problems.

Rabab Ward, CICSR Director

Jaeger: continued from page 1

power metering and management. As a result, Carmanah Engineering in partnership with UBC developed an integrated-optics based technology to measure voltage on transmission lines.

A honey of a deal

Meanwhile, the Space and Aviation Controls Division of industry giant Honeywell had spent 10 years developing fibre optic sensors that measure current. However, the market need was for a product that could measure both voltage and current—and Carmanah Engineering was the company with the best optical voltage measurement technology. Talks between the two companies began in June 1998, and in November 1999, through a merger of Carmanah Engineering and a spinout group from Honeywell, NxtPhase Corp. was formed.

"Power is measured for all sorts of reasons other than just metering for billing purposes," says Jaeger. "For example, with deregulation you get into issues of power quality, and to determine the quality of power you have to be able to measure it with a high degree of accuracy over a wide bandwidth. That's where our technology really comes into its own."

Integrated Optics Pockels Cell technology

One of the keys to the company's success is the Integrated Optics Pockels Cell (IPOC) technology developed by Jaeger and used in NxtPhase's Optical Voltage Transformer. It is based on the Pockels effect, where the change in the refractive index of a crystal is in direct proportion to the applied electric field. Coupled with the Optical Current Transformer developed by Honeywell, NxtPhase's combined voltage and current transformers are smaller, lighter and more flexible than those currently on the market. A single unit can be used to meter power as well as monitor and control the flow of electricity.

The product has safety and environmental advantages as well. Most of the high-voltage instrument transformers currently installed in substations use oil and paper insulation systems, which can be harmful to the environment and, in the event of a power failure, can explode. NxtPhase's optics-based systems use a very simple and safe insulation—dry air.

"Oil and paper insulation was the solution available when the currently installed power infrastructure was being developed," says Jaeger. "However, as we get better materials we can take advantage of what seems to be simpler and more logical technology."

"...as we get better materials we can take advantage of what seems to be simpler and more logical technology."

Mutual benefits

When asked about his ongoing involvement as scientific advisor with NxtPhase, Jaeger likes to call himself "the university guy." He says the benefits of this university-industry partnership flow both ways. "We have an outstanding relationship with NxtPhase. Two of our NSERC scholars are working on projects with them and they provide tremendous opportunities for our co-op and graduate students."

The company and university benefit in other ways as well. For example, as a result of their collaboration on optical voltage sensors, NxtPhase and UBC were recently presented with the Canadian Institute of Energy's 1999 Energy Research and Development Award.

NxtPhase continues to be very involved with research, Jaeger notes. "The company's interest isn't limited to what we can do for power utilities, but also what technologies we can develop for the future."

Nick Jaeger can be reached at nickj@mech.ubc.ca and at (604) 822-5673.

Computing Complex Problems with DNA

Anne Condon searches for more efficient ways to solve computational problems.

Computational complexity theory may not be everyone's favourite dinner topic, but with demands on computing resources rapidly increasing, the research of theoreticians is more critical—and topical—than ever. CICSR member Anne Condon finds theoretical work fascinating because it provides a unified view of phenomena that intersect all applications of computing. The existence of inherently difficult (so-called NP-hard) problems is one such phenomenon that has motivated much of her work and has recently led her to explore computations with DNA.

The hard problem of a flight path

One of the most well-documented NP-hard problems is the Hamilton path problem, or how to map out an airline flight path between several cities so that each city is visited only once, and the cost to the airline is minimized. "With a problem like the Hamilton path you have a number of potential solutions, of which perhaps only one is a true solution. The really onerous task is how to weed through all the possibilities to find the one you want," says Condon. "Unfortunately, no one knows of an approach for solving this problem that avoids an exponentially large computational running time."

Using DNA to solve NP-hard problems

In 1994, theoretician Leonard Adelman actually solved a small, seven-city version of the problem using DNA. His astonishing work captured Condon's interest. Adelman's idea was to represent each possible solution as a DNA strand. Representing information at the molecular level could in principle allow for huge numbers of strands—or potential solutions—to be examined simultaneously.

"With DNA computing it is not the running time that grows exponentially, but the number of molecules used," Condon notes. "Since we can only fit so many molecules into a test tube, we still run into the exponential barrier." In spite of this, developing tools for manipulating and retrieving information coded in vast quantities of DNA is an intriguing challenge. For the past four years, Condon and associates in the chemistry department at the University of Wisconsin have been developing these tools. Their work has recently appeared in the journal *Nature*.

Condon came to UBC's Computer Science department last August. While she plans to continue with her research in DNA computing, she says part of her decision to move to Canada was the quality of research and the opportunities available at UBC.

She is currently working with colleague Alan Hu and graduate students Rita Sharma and Marius Laza on the problem of automatically verifying shared memory protocols. She also participates in Computer Science's Bioinformatics reading group established by Raymond Ng.

"I have been lucky to meet several researchers in other departments on campus through events at the Peter Wall Institute for Advanced Studies." Condon also cites PIMS (The Pacific Institute for the Mathematical Sciences) and ASI (the Advanced Systems Institute) as providing great opportunities to make research connections.

Supporting women in science

Condon's position at UBC is partly funded through the NSERC Research Chair for Women in Science and Engineering. She is co-chair of the Computing Research Association's Committee on Women, a North American organization that coordinates projects aimed at supporting women in computing research. Condon works with SWIFT (Supporting Women in InFormation Technology) led by UBC's Dean of Science Maria Klawe, and she recently worked with members of the Women's Studies department to design an introductory course aimed at drawing more women to computer science.

Anne Condon can be reached at condon@cs.ubc.ca or (604) 822-8175.

CICSR researcher Anne Condon is Program Chair for the 2000 International Conference on DNA-based Computation in Leiden, Netherlands, in June.

Mechatronics—Engineering the Future

Clarence de Silva integrates mechanics, electronics and intelligent control to increase industrial productivity.

Engineering systems that improve industrial productivity is an increasingly complicated challenge—one that involves integrating knowledge from many disciplines. British Columbia's fish processing industry provided the perfect opportunity for CICSR member, professor of Mechanical Engineering, and ASI Fellow Clarence de Silva to put his expertise to the test.

Cutting fish with fuzzy logic

As the NSERC Research Chair in Industrial Automation, a position established in collaboration with BC Packers Ltd., de Silva established the first—and only—laboratory in Canada to develop an automated system for fish cutting and processing. The industrial prototype developed by de Silva and his associates produced clear-cut results. Plant testing with thousands of salmon at BC Packers has shown that the new machine can increase cutting and fish recovery efficiency by five percent over conventional methods, which can waste over a pound of meat per fish. Since each percent equals about $5 million worth of fish, the cost recovery for the industry is significant.

The machine uses a variety of sensors such as CCD cameras, an ultrasound scanner, and optical encoders to accurately monitor the geometry and movement of a fish. Advanced controllers reposition the cutter for each fish in order to maximize recovery. "Our system is a knowledge-based, hierarchical system, which means it has many levels of intelligence," says de Silva.

The knowledge base of the system captures human experience and expertise as a set of "fuzzy" rules that translates the human decision-making process into system software. Fuzzy logic is used in the higher levels of the system to carry out process monitoring, performance evaluation, quality assessment, system tuning, and general supervisory control.

Clarence de Silva recently received the Education Award from the Dynamic Systems and Control Division of the American Society of Mechanical Engineers and the Killam Research Prize from UBC.

Technology transfer

De Silva, colleague Elizabeth Croft, and graduate student Iwan Kurnianto have also developed a machine that automatically grades herring roe. "For this product, quality control is extremely important. You need to maintain a grade which is repeatable and predictable," says de Silva. While the downturn in BC's fishing industry has delayed the implementation of these automated systems, the technology has been successfully transferred to other industry sectors. PRECIX Advanced Cutting Technologies are using the same controller developed by de Silva and PhD student Scott Gu for the robotic fish cutter to cut plastic and apply glue in their router machines. The forestry industry is using another offshoot of the same technology for wood-drying kilns.

Continuously variable transmission

Industrial automation is only one area of de Silva's expertise. Another ingenious and purely mechanical innovation is the Ivana Continuously Variable Transmission (CVT). Unlike the familiar stepped gear arrangement in cone and belt and hydraulic systems, CVT uses conventional components with a minimum of moving parts to increase the drive ratio in a constant curve. It is ideal for low-budget applications, such as bicycles. The Ivana CVT has recently

continued on page 8

Modelling the Electromagnetic Earth

Uri Ascher is seeking faster solutions to the inverse electromagnetic problem.

Uri Ascher investigates computer methods for solving complex mathematical models. The computer science professor develops reliable and more efficient ways for solving the computational problems that arise in such areas as robotics, mechanical systems simulation, geophysics, and computational fluid dynamics. The work is critical to software development in those areas.

Imaging the earth's interior

Ascher's recent work on a 3-D geophysical data inversion project will have direct application in geophysical surveying and mineral exploration. Ascher is co-investigator of the IMAGE consortium, a university-industry collaboration that is developing state-of-the-art computer technology to image the earth's interior using electromagnetic models and data. He is also a CICSR member and Computer Science professor.

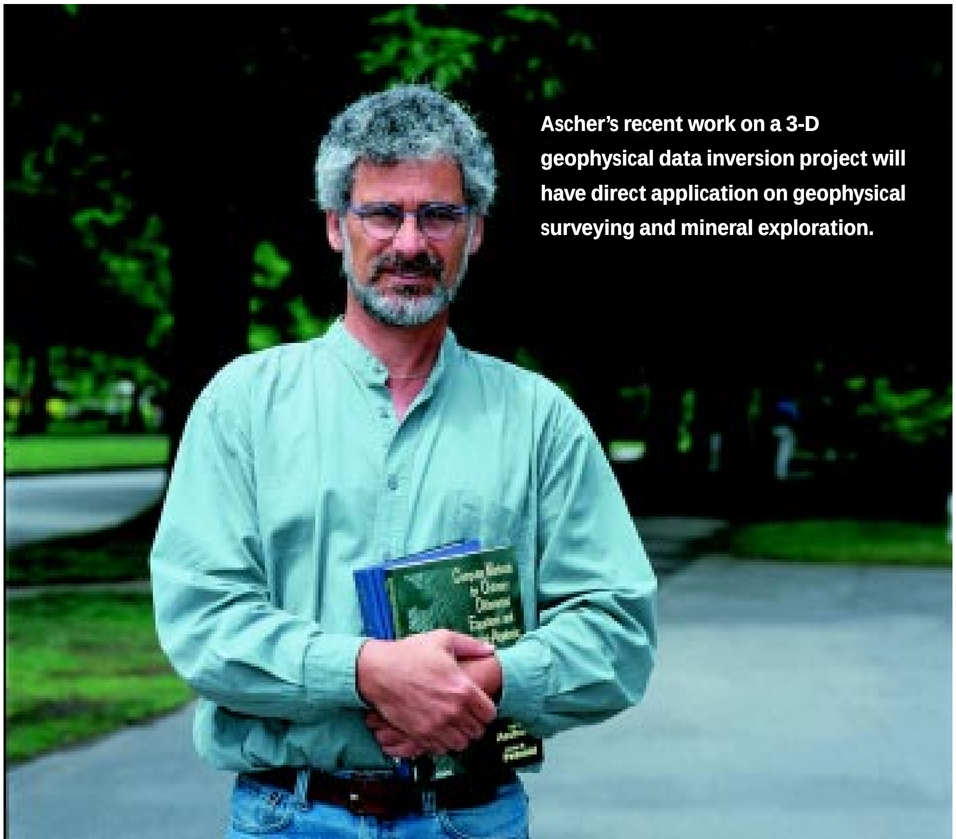
IMAGE stands for Inversion and Modelling of Applied Geophysical Electromagnetic data. Electromagnetic data is acquired during geophysical surveys and helps scientists to determine the physical properties hidden beneath a given area of the earth's surface. The problem is known as the 3-D inverse electromagnetic problem and IMAGE is seeking more reliable and faster ways of solving it.

One material property of special interest is conductivity, as its distribution can indicate the presence of valuable minerals. A complex transformation is required, however, in order to deduce the conductivity structure from electromagnetic observations.

This transformation, called forward modelling, involves the repeated computer solution of a system of partial differential equations in 3-D, known as Maxwell's Equations.

Collaboration leads to results

The IMAGE project is a collaboration between the Geophysical Inversion Facility, headed by Doug Oldenburg, a professor in UBC's department of Earth and Ocean Sciences, and the Scientific Computing and Visualization Group at CICSR. Spearheaded by Eldad Haber, a postdoctoral fellow jointly supervised by Ascher and Oldenburg, and with the participation of Dhavide Aruliah, a Computer Science PhD student, the IMAGE team has worked out new techniques for solving realistic instances of the forward modelling as well as sparse matrix techniques to rapidly compute the inverse problem.



Ascher's recent work on a 3-D geophysical data inversion project will have direct application on geophysical surveying and mineral exploration.

"What the companies are after is the results of the data inversion," says Ascher. "For instance, since metals often conduct much better than earth, the results of the data inversion may tell them where the minerals are or aren't."

Oldenburg notes that the IMAGE program can also be used to detect other subsurface objects, such as unexploded ordnance or contaminants. "Anything that has an electrical conductivity contrast with its host."

It is expected that the IMAGE project will be sponsored by NSERC through their Industry Partnerships program. The consortium's ten sponsors include such leading mineral resource companies as Falconbridge, Placer Dome, Anglo American, INCO, and Cominco.

The sponsors will supply the data on which the inversion codes will be tested, and the codes will be made available to the sponsors at the end of the three-year project.

Similarities span research fields

Ascher's work with IMAGE has similarities to problems he encounters in completely different areas such as reality-based modelling and the simulation of physical systems in virtual environments.

"I find it satisfying that computational techniques from one area can be ported to completely different areas," Ascher says. "Methods used to model and simulate fluid dynamics, for example, are similar to those used to simulate electromagnetic fields.

In addition to his IMAGE work, Ascher is also interested in writing general-purpose mathematical software, investigating parallel algorithms and optimization techniques, and getting more specifically involved in particular application areas.

His work on IMAGE, however, had a different feel than his other research.

"This is a program that companies can use for actual decision-making," says Ascher. "It's something more directly applicable than anything I've ever worked on before."

Uri Ascher can be reached at (604) 822-4907 and ascher@cs.ubc.ca

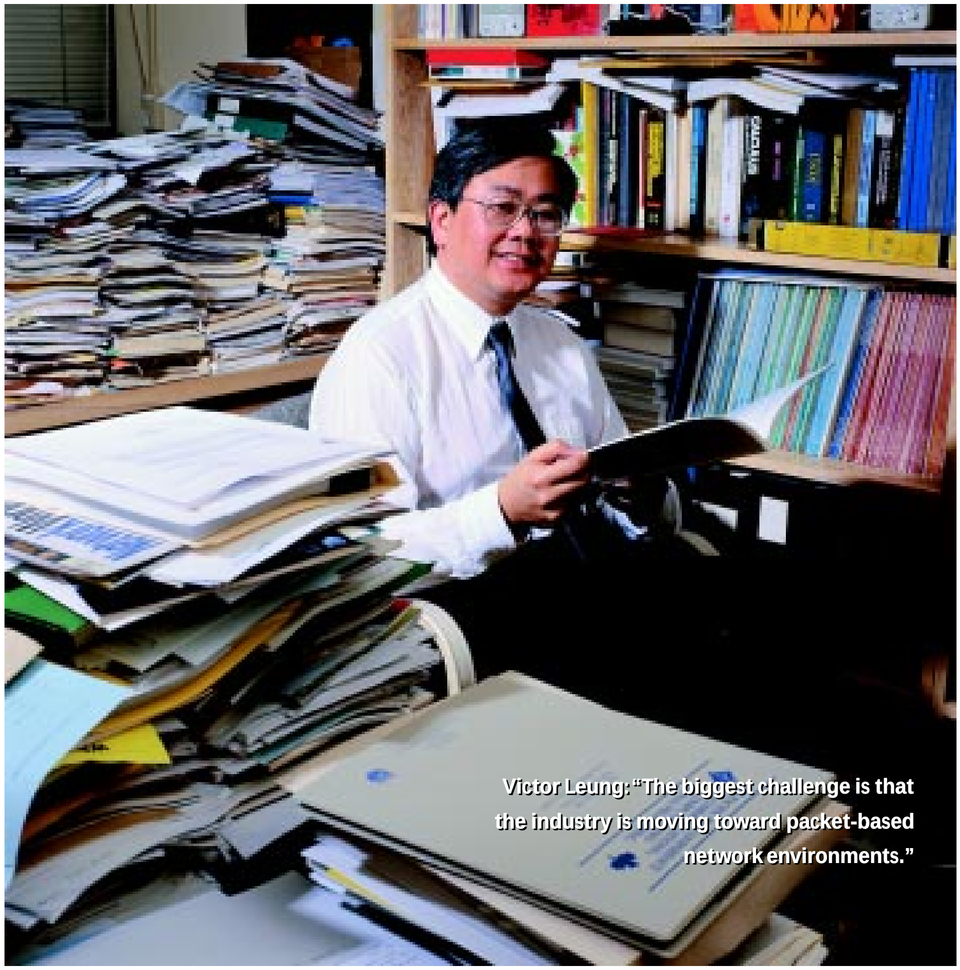
UBC-TELUS Alliance Supports Advanced Telecommunications

Victor Leung searches for seamless, wireless mobility.

The exponential growth of the Internet as the global communications network of choice has posed some unique problems, particularly for mobile telecommunications. Victor Leung, CICSR researcher and professor in the Communications Group, Department of Electrical and Computer Engineering, was recently appointed the TELUS Mobility Research Chair to try to come up with workable solutions.

Leung is highly qualified for the task. He has been a researcher and professor in the field since 1987, and a project leader in the Canadian Institute for Telecommunications Research, a Network of Centres of Excellence. Prior to that, he gained six years of industry experience in satellite communications systems with Microtel Pacific Research Ltd. (later known as MPR Teltech Ltd.). "MPR was the research and development subsidiary of the former BC Tel before it merged with TELUS, so I guess I am not unknown to the TELUS family," he says.

In addition to their pledge of $500,000 for the Research Chair, TELUS will be funding programs to support information technology on campus, as well as specific research projects in advanced communications technologies.



Victor Leung: "The biggest challenge is that the industry is moving toward packet-based network environments."

Packet-based wireless networks

"The biggest challenge is that the industry is moving toward packet-based network environments," says Leung. Packet-based networks allow better management of data transmission and routing by segmenting information into manageable "chunks." The difficulty is that wireless networks are traditionally non-packet-based. In circuit-switched wireless networks a channel is set up for each call. Since, in most conversations, only one party speaks at a time and over half of that time is spent listening, using a channel full time for a two-way conversation is very inefficient. "Packetization allows a number of different conversations from different parties to be multiplexed over the same channel in order to use the bandwidth more efficiently."

Packets can also facilitate video conferencing, where a video encoder generates the traffic at different bit rates depending upon the amount of motion observed in the video sequence. Packet-based networks are better designed to handle this fluctuation in data transmissions. However, when handling real-time traffic, such as digitized voice and video, the amount of delay the different packets can experience is constrained.

Quality of service & mobility management

Just like a freeway at rush hour, network traffic can become bottlenecked. Some types of traffic have more stringent delay requirements. Also the Internet—which is now used for most network traffic—was originally designed to offer "best-effort" service. This has posed major quality-of-service (QoS) problems, particularly when it is used for premium services such as banking, private corporate networking, or real-time services such as voice or video. Different multimedia applications have different QoS requirements and the difficulty is not just maintaining QoS, but managing the traffic according to these various specifications while maximizing the amount of traffic the network can handle. This is where traffic scheduling and shaping mechanisms come in to play. Motorola and NSERC have provided funding for Leung and

continued on page 8

CICSR Passing Notes

Christina Conati (CS) is a new member of CICSR and a new appointment to the Computer Science department. She arrived at UBC in October direct from the University of Pittsburgh where she received her PhD in August of 1999, and her MSc in Intelligent Systems in 1996. Before that she was a research programmer at Carnegie Mellon University where she conducted research on computational cognitive modelling. Her research interests include artificial intelligence, user modelling, adaptive interfaces, intelligent educational and help systems, reasoning under uncertainty, and cognitive theories of learning.

James Olson is a new CICSR member and assistant professor in the department of Mechanical Engineering. He is also a member of the Advanced Papermaking Initiative (API), and a faculty asssociate of Paprican. His research is focussed on the application of physics and fluid mechanics to problems associated with the pulp and paper industry. His current research projects include modelling turbulent fibre suspensions; advanced screening simulation; and the development of a high-efficiency, continuous laboratory fractionator.

Gary Schajer is a mechanical engineering professor and new CICSR member with interests in advanced processes for grading lumber; dynamics and stability of circular and band saws; and computational methods for residual stress analysis.

W. Kendal Bushe is a new CICSR member and assistant professor of mechanical engineering whose research interests include combustion; turbulence; numerical simulation; computational fluid dynamics; IC engines; and thermal power generation. His current research is centred on the development of techniques for the numerical simulation of turbulent reacting flows.

Gregor Kiczales joined the Computer Science department and CICSR in January 2000. He comes to UBC after 15 years at the Xerox Palo Alto Research Center, where he was a Principal Scientist and manager of the Software Design area. "My belief is that programs that clearly express the design structure they implement are easier to maintain.... In pursuit of this goal, most of my research has been in programming language design and implementation, but I am also interested in programming environments, design and coding styles, and software engineering principles."

Frank Lam is a new associate member of CICSR. He is an associate professor in the Wood Science department and his research interests include mechanics of wood-based composites; structural behavior of engineered wood products and systems under static and dynamic loads; random field-based structural analysis models to account for the stochastic nature of the material properties; and grading techniques to improve structural reliability and product performance.

CICSR is pleased to welcome **Peter S. Sapaty**, an ASI Visiting Fellow from the Ukraine. Peter is head of the department of Distributed Control, Simulation, and Virtual Reality at the Institute of Mathematical Machines and Systems, National Academy of Sciences of Ukraine. His interests include models, languages, technologies for cooperative processing and control in open computer networks, and collective behaviour of robots.

The new Master of Software Systems (MSS) program is off to a successful start, with 25 students entering the first term in January. Applications for January 2001 are already pouring in. The program is designed for students with science or engineering backgrounds, other than computer science and computer engineering. Please visit www.cicsr.ubc.ca/mss/ for more information.

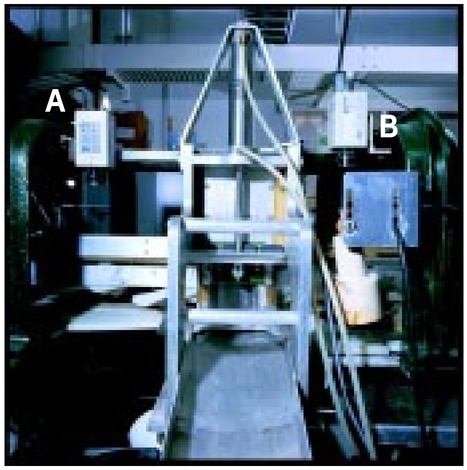
CICSR has submitted an infrastructure funding proposal to the Canada Foundation for Innovation (CFI) for $22 million to establish a new multi-disciplinary research facility, the Institute for Computing, Information and Cognitive Systems (ICICS). As CICSR evolves into ICICS, it will include researchers from all disciplines in the arts, humanities, sciences, medicine, business, engineering, and the educational, social, health, and behavioural sciences. ICICS researchers will collaborate on integrating the different aspects of human experience into the broad application context of interactive information environments. This concept becomes increasingly pivotal as the information and communication technologies permeate deeper into every aspect of human society. The CFI decision is expected at the end of July.

Clarence de Silva: continued from page 4

been issued a US patent and is being promoted in Asia. (It is in Asia, de Silva notes, where fuzzy logic was first embraced, since the word “fuzzy” has more positive philosophical connotations in the East than it does in the West.)

Writing and practicing what he teaches

De Silva also continues to do research in space robotics, conventional sensor technology and computer vision. He has authored 12 technical books, edited six volumes, and written over 100 journal papers. He has developed courses and written textbooks for many research areas, including intelligent control, control sensors and actuators, process control, and dynamic systems modelling. De Silva’s most recent textbook *Vibration: Fundamentals and Practice* was published by CRC Press last December. Recognized as a leading expert in his field, he is sought after to conduct professional development courses around the world.



Cameras (A, B above) are an integral part of the automated fish processing system.

What would he still like to accomplish? De Silva’s dream is to establish a program in mechatronics to teach the integration of electronics, mechanics and intelligent control in systems design and development. He co-developed—and serves as advisor for—a graduate program in mechatronics at The National University of Singapore.

“As with the application of fuzzy logic in industrial automation, researchers at UBC are able to take a leadership role in the field of mechatronics,” states de Silva.

Considering where the industry is headed, and the collaborative nature of his work, mechatronics at UBC is a dream from which industry, the university and its students would certainly benefit.

Clarence de Silva can be reached at desilva@mech.ubc.ca and at 822-6291.

Victor Leung: continued from page 6

co-investigator Hussein Alnuweiri to pursue research in traffic control and QoS management for packet-switched mobile data networks.

While the goal of public wireless networks is to provide multimedia services at a much higher data rate than what is currently available, one of the key issues remains reliability. “If you consider that the traditional telephone networks were designed to be very reliable, and various parts of the wireless Internet weren’t really designed that way, there is still a lot to be done to make the wireless Internet as reliable as the plain old telephone networks.”

Leung acknowledges the importance of industry partners such as TELUS, Motorola Canada Ltd., and Com Dev International, as well as ASI and NSERC in funding his research and providing opportunities for students. Many of his graduate students are working for PMC Sierra and other BC companies.

As a professor and senior researcher, Leung helps to set students on career paths in both industry and academia. He is proud that two of his PhD students have gone on to teach at other universities. “One of my Master’s students, Jean-Francois Frigon, won the Governor General’s Gold Medal,” Leung adds, remembering his days as a student and gold medal winner at UBC. “I did my undergraduate and graduate work at UBC. In fact, I have spent most of my life here,” he laughs. Clearly, it is a life he relishes.

Victor Leung can be reached at vleung@ieee.org or at (604) 822-6932.

CICSR Centre for Integrated Computer Systems Research www.cicsr.ubc.ca

The UBC Centre for Integrated Computer Systems Research (CICSR) is an interdepartmental research organization made up of computer-related research faculty members in the departments of Computer Science, Electrical and Computer Engineering, and Mechanical Engineering. Currently, there are 80 CICSR faculty members who direct approximately 350 graduate students and collaborate with dozens of industrial firms in areas such as robotics, artificial intelligence, communications, VLSI design, multimedia, and industrial automation.

Return Address:

CICSR, University of British Columbia
289-2366 Main Mall, Vancouver, BC, V6T 1Z4
CANADA

Writer: Mari-Lou Rowley, Pro-Textual Communications
Design: William Knight, wilyum creative
Photos: Janis Franklin, Biomedical Communications
Office: University of British Columbia
289-2366 Main Mall
Vancouver, BC, Canada, V6T 1Z4
Tel: (604) 822-6894 **Fax:** (604) 822-9013
E-mail: cicsrinfo@cicsr.ubc.ca
Contact: Linda Sewell, Publications Coordinator, CICSR Office