Foreseeing problems, finding choices

Bridget Hourican looks to 4C, one of the world's leading academic constraint programming labs, for solutions to today's problems

A multinational involved in manufacturing wants to know if it's getting the best out of its current equipment before it invests in new equipment;

A hospital wants to ensure it has all the supplies it needs on hand, without necessarily increasing its supply storage space;

A travel agency wants to make it easier for customers to configure their dream holidays;

A restaurant wants to take bookings, making optimum use of its seating capacity and taking into account cancellations and no-shows;

And commuters on trains want to complete Sudoku.

What all these situations have in common is that they're constraint problems. All have been solved, or are in the process of being solved by 4C, the Cork Constraint Computation Centre (therefore the 4 Cs, although the name is also of course a pun on 'foresee'; the centre foresees difficulties and solves them before they become a 5th C - crises!)

Researchers at 4C develop the technology and underlying science which, as Dr Eugene Freuder, director of 4C, puts it: 'help computers to help individuals and companies to make better decisions.'

The above examples are only a few of the common constraint problems that businesses and individuals run into on a daily basis. It's easy to see why Dr Eugene Freuder, director of 4C, now thinks 'all problems are constraints problems.'

Professor Eugene Freuder

CONSTRAINTS

Sudoku is a 'classic constraints problem' that can serve as a paradigm. 'Constraint problems involve variables, values, constraints, and, optionally, preferences and uncertainties. In Sudoku, the cells are the variables, each cell can take on a value of 1 to 9, and the constraints are the game rules.' (Ok, there are no preferences or uncertainties but Sudoku isn't the real world). Freuder says: 'If you can solve Sudoku, you're a constraint programmer.' I ask hopefully if he wants to give me a job...

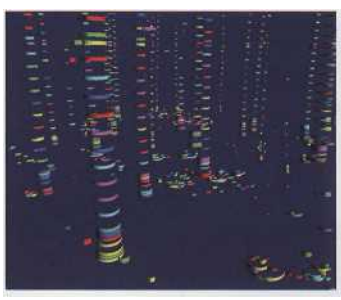
Applied to a real-world problem like staff rostering, the paradigm holds - the variables are the employees; preferences could include how colleagues get on together and when they want to take their annual leave; and uncertainties could come into play with sick leave and, say, early maternity leave (because babies don't follow rules as strictly as Sudoku numbers).

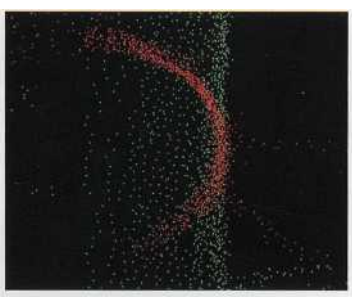
PUT THE LOAD ON THE MACHINE

4C was established as part of the Department of Computer Science of UCC in 2001, when Dr Freuder was brought over from the University of New Hampshire to head the new centre, which has since grown to over 40 people - including academics, staff and students. Freuder has a strong international profile: is a Fellow of the American Association for the Advancement of Science (AAAS), and has recently been made a member of the Royal Irish Academy. 4C has won numerous awards for its research and members, including recently the Rob Milne Memorial Award for the best refereed application paper at the 26th SGAI International Conference on Innovative Techniques and Applications of Artificial Intelligence, and an Industrial Paper Prize at the 12lh IFAC Symposium on Information Control Problems in Manufacturing.

Among the factors which put 4C at the forefront of constraint programming is Freuder's artificial intelligence (AI) background; 'I bring inference and other AI techniques to bear on constraint programming.' The idea behind one of 4C's projects, ACE

TreeMetrics Software





(Automated Constraint Engine), is to make computers learn from experience. 'We're trying to put more of the burden on the machine and less on people - that way people don't need specialised knowledge to make key decisions.'

Freuder is keen to keep constraint programming non-specialised. A new Enterprise Iraland-funded programme, 'CP Inside', is looking at how to embed constraint software into popular software, like *Outlook, Notes* or *Google Calendar,* so that users don't need to learn new programming. 'It's the Trojan horse approach!'

INDUSTRY PARTNERSHIPS

Core funding for 4C comes from Science Foundation Ireland, but the EU, Enterprise Ireland, and the Embark Initiative have all supplied grants, and industry has partnered numerous projects. Since its foundation, 4C has received about three dozen grants, totalling around €20 million. It currently has about '20 projects running, with industry involvement in around half,' says Dr James Little, external liaison officer.

4C has an Industry Associates Program 'with over 50 members', says Little, 'and a contact database with over 250 entries.' The purpose of the Industry Associates Program is to foster technology transfer and industry outreach and to offer opportunities for collaboration between industry and 4C.

Projects run the gamut from those with multinationals, like *Lucent, Xerox* and *Bausch & Lomb* - 'our first Enterprise Ireland Innovation Partnership Project was with *Bausch & Lomb',* says Little, 'we designed a system to show how they could improve scheduling, and answered many of their what-if questions about scheduling the factory' - to projects with local Irish industry, like *TreeMetrics,* an Irish software company currently developing a 3-D system to measure standing trees in the forest. The system will provide more accurate measurements of quantities of timber for merchants and growers. 4C is helping develop the software - using case-based reasoning to predict shapes of high branches that the laser scanner can't see - and is also developing a supply chain model to help *Treemetrics* go to the next level.

Another project Little is enthusiastic about is 'TalkingShop', a three-year Enterprise Ireland-funded commercialisation project he co-directs with Dr Derek Bridge. Talking Shop is a sophisticated recommender system, the brainy big brother of systems like Amazon's which try and match your profile to a book or CD. It's one thing with fixed products, but gets seriously tricky with products like holidays and property, which have endless permutations. Talking Shop is a flexible search engine, which shows you the myriad of possibilities, and lets you shuffle your preferences. A local Cork travel company, *My Guides Ireland,* is now in discussions with the centre to incorporate the Talking Shop software into its website.

Dr. Barry O'Sullivan

COMMERCIALISATION: FROM BLUE SKIES TO THE MARKET

Some of 4C's projects start with a specific problem-solving request from an individual company, others arise from basic research. Dr Barry O'Sullivan is the principal investigator of an El-funded project, RECAP, which started this year. RECAP stands for Robust and Expressive Combinatorial Auctions for Procurement. 'It's a 3-year commercialisation grant, but it follows on from a series of earlier grants. The idea started with a PhD by one of my students, Alan Holland; we then applied for a one-year Proof-of-Concept grant, and now we're at the commercialisation grant stage.'

RECAP is about supporting combinatorial auctions in large industrial and public sector procurement settings. Combinatorial auctions allow small suppliers to competitively offer large companies a package of goods and services that they would not be otherwise able to supply if each item was associated with its own standalone procurement contract. O'Sullivan explains: 'Instead of big companies buying goods and services on an item-by-item basis, they accept bids from the market on combinations of items, which often results in significant procurement cost savings. It's a win-win situation: it's cheaper for large companies to satisfy their procurement needs, and small suppliers can exploit their internal efficiencies to competitively bid for combinations of goods and services.'

RECAP differs from other combinatorial auction tools by focusing on robustness - if a company announces who's getting which combination, and one of the winning suppliers backs out, the company risks being stranded with a set of items they cannot purchase without paying a high premium. However, the technology being developed under RECAP ensures that such eventualities can be easily overcome by guaranteeing other suppliers can step in for a controlled increase in procurement cost. This is particularly important in political contexts - such as for example a government buying flu vaccines from a geographical mix of suppliers could be left in an embarrassing situation if a supplier backed out and there was a shortfall - with RECAP that won't happen.

4C is excited about RECAP and is in talks with UCC about setting up a company. O'Sullivan says: 'We're planning for Alan Holland, my former PhD student, to be CEO of the new company, which should be up and running at the end of the year. I like the way it all grew from basic research - and Alan's now doing an EnterpriseStart Programme to get into the business mindset!'

4C's website is at http://www.4c.ucc.ie. General enquiries to Eleanor ORiordan, (021) 4255400; Industry enquiries to Dr James Little, (021) 4255410 You can also speak to the team at Enterprise Ireland or Gearoid Mooney at gearoid.mooney@enterprise-ireland.com

LICENSING WITH ALCATEL-LUCENT

In October 2006 *Alcatel-Lucent,* the telecommunications specialists, asked 4C's help with manufacturing and scheduling issues at their plant in Columbus, Ohio. Dr James Little and Dr Roman van der Krogt, a 4C PhD researcher, spent a week in discussions with *Alcatel Lucent,* and during this time developed a prototype model using constraint programming technology, which met the needs for scheduling their new plant layout. The changes to the company's manufacturing design necessitated the need for better understanding of cell utilisation, and especially the scheduling of fewer changeovers. The prototype was subsequently developed back at 4C, providing an interface and carrying out further trials on live data. Within four months the first results were being used as the basis for *Alcatel Lucent's* weekly work schedule.

The project was carried out in connection with 4C's participation in the SFI-funded Centre for Telecommunications Value-chain Research (CTVR), where 4C leads the Optimisation & Management strand. Within the agreement of the CTVR project, Alcatel-Lucent will be provided with a licence for this technology.