Improving access to hospital treatment & cloud services

A cancer pathway mapping project jointly led by three University of Auckland mathematicians is improving access to treatment for patients with breast cancer at North Shore Hospital.

Dr Michael Justin O'Sullivan*, right, and Associate Professor Cameron Walker co-direct Operations Research Union Analytics (ORUA) in the Department of Engineering Science, and Associate Professor Ilze Ziedins is Head of the Department of Statistics.

Orua means 'to coincide' in Māori and "we think about Operations Research as engineering, mathematics, computer science and management science coinciding to improve whatever system we are modelling," says Michael. "We build and solve mathematical models to help decision-makers."

ORUA applies mathematical modelling, operations research, and analytics to computing technologies, financial systems, infrastructure planning, biological and transport systems, and started providing Modelling-as-a-Service to DHBs in 2009. The mapping project tracked Waitemata DHB's breast cancer pathway from referral to first specialist appointment; the decision to treat; and then to the first treatment appointment.

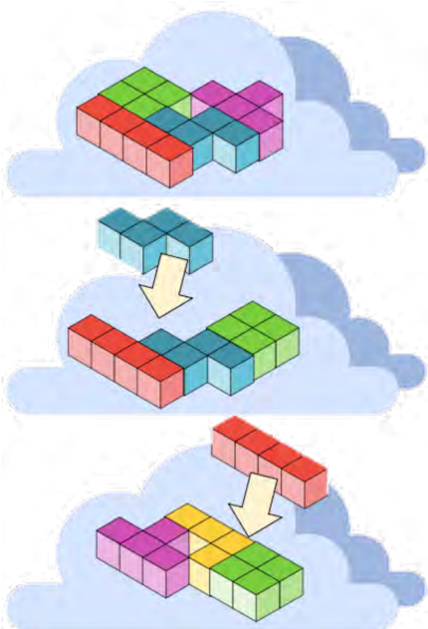
The project found that the DHB needed to reduce the time between any two steps to improve clinical outcomes for patients, and meet government targets for treating women with breast cancer. The DHB is now consistently meeting the 2016 target of 85 percent of women with breast cancer being treated within 62 days, and is working with the team's recommendations to meet the 2017 target of 90 percent.

The team also identified the delay points in treatment for gynaecological, colorectal and upper gastro-intestinal cancers, enabling the DHB to focus on these points. "In upper GI cancers, the main delay was in the step from the decision to treat until the first treatment appointment, largely due to the need for imaging. Having this information meant the DHB could directly address the need for radiology services."

ORUA is working closely with Dr Jonathan Wallace from Waitemata DHB on the Acute Surgery Redesign project, and is part of a research partnership with software developers Orion Health. "We want to generalise our work for general medicine to any department in the hospital," says Michael. "I'd like to build a cloud-based service like Gmail that uses DHB rules, staffing levels, patient admission and discharge rates to automatically build optimal staff rosters."

Students of the three mathematicians have successfully modelled patient flow to evaluate rosters for general medicine registrars, and developed an optimised roster that shares workloads and shifts more equally among doctors. They've also developed a simulation that assigns queues of laboratory tests to cytologists to determine the most appropriate staffing, and an integrated simulation/optimisation model to improve dispatch policies for orderlies moving patients around a hospital for tests or treatment. The demand for modelling analytics from DHBs continues to grow, and the group is also providing analytics to other government agencies.

Michael O'Sullivan and two of his four children at Bryce Canyon in Utah.



Computing in the cloud

Another major area of work for ORUA is building intelligent cloud computing systems. The physical part of a computing cloud in New Zealand may be a warehouse of computer servers in Sydney, but a virtualisation layer allocates services such as online gaming to individual virtual machines hosted by these servers. ORUA PhD students have written optimisation algorithms enabling the allocation of virtual machines to be tailored "on-the-fly", improving performance without requiring more servers.

"If I want to edit videos and another user is playing an online game, we'd get poor performance if we used the same server because

$$OpEx=\sum_{v\in V, r\in R} L(Pw(r)+Ro(r))x_{v,r}$$

both of us need the same graphics processing card. But if the virtualisation layer moved the virtual gaming machine to a different server, both of us would get better performance. Imagine that multiplied by thousands of servers and hundreds of thousands of people – orchestrating cloud infrastructure is still a work in progress."

ORUA has built a test cloud lab in the Engineering Science department to develop intelligent cloud systems that provide computer-aided design (CAD), video gaming, and video editing on thin client terminals - lightweight computers designed to connect to servers hosting virtual machines running these services. "A simple tablet or computer with good connectivity can have two windows for two different virtual computers running difference processes."

ORUA has found a niche in developing software for metropolitan area clouds – cloud servers for a small area that enable people in internet cafes to play online games and nearby residents to stream HDTV, because the content is geographically close. Michael, Cameron and colleagues have set up the Green Cloud Innovations company to commercialise their intelligent cloud technology; green because their software can ensure that a cloud uses as little power as possible.

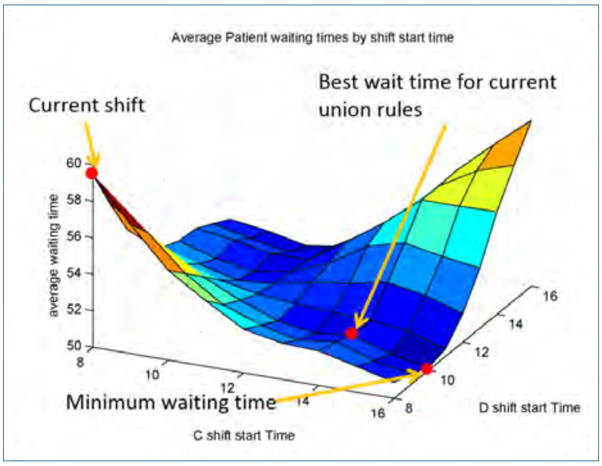
"We're working with people in China who have 800-seat internet cafes, and our software has been installed in a 50-person café. As long as you have reasonable bandwidth, you can play high-end games on a mobile device; without the cloud you can't because high-end games need more graphics power than mobile devices have."

"With this new infrastructure, you can play a game with a friend and on your iPad you can watch what she's doing while you're playing. If you get stuck in a game, you can slide your virtual machine to her computer so she can get you unstuck and give it back. There are ways of doing that with video editing and CAD design in the cloud, but they're pretty clunky. We provide a cleaner way."

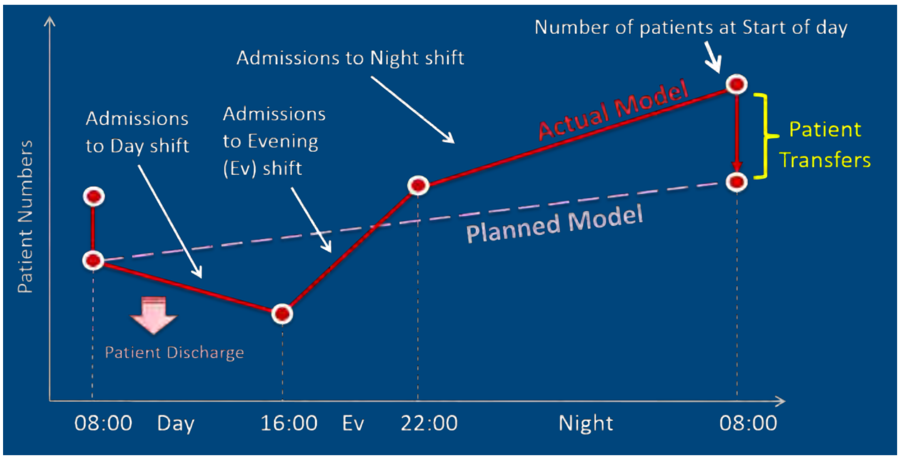
Michael says the paradigm is the same for cloud manufacturing. "Someone logs into the cloud with the specs for their product, and the cloud calls for production and transport quotes from different manufacturers. The intelligent part is orchestrating the network of manufacturers and transporters to reduce costs."

In 2010, Michael led the development of DipPy, a new interface for advanced optimisation programming, which has since been downloaded over 300,000 times. DipPy was created with PuLP, a Python-based mathematical programming language, which was "glued to an advanced optimisation solver called Dip. It enables students to do advanced optimisation easily, and we've used it to solve real-world consulting problems. In some cases it's competitive with commercial solvers."

"I use maths as a language to describe the real and virtual worlds. I love it because I see what it can do in the real world, helping people and helping governments invest wisely."



Michael O'Sullivan and Cameron Walker supervised Amelia White's project to model the timing of registrar rosters. She found that changing the start times of registrar shifts to align with peak patient arrival times would reduce waiting times by at least 14 percent.



O'Sullivan and Walker also supervised Hanieh Sanei, who developed an optimisation model to generate automatic rosters for registrars at Auckland Hospital. Her rosters shared their workload fairly and minimised the transfer of patients between registrars.

*As distinguished from his father, Professor Michael John O'Sullivan, also a mathematician in the same department.

Download DipPy from: https://projects.coin-or.org/Dip/wiki/DipPy

See the ORUA website: http://twiki.esc.auckland.ac.nz/bin/view/ORUA/WebHome

More about cloud computing: http://www.engineering.auckland.ac.nz/en/about/our-research/iande-research-theme/cloud-computing-1.html

More about cutting hospital waiting times: http://www.engineering.auckland.ac.nz/en/about/our-research/health-research-theme/hospital-wait-times.html