From IMAges 12, July 2012

Better cycling networks

Andrea Raith, right, now a lecturer at the University of Auckland, is at the leading edge of traffic problem solving.

She started by developing solution methods for the design of wind turbines in Germany as part of her studies at the Technische Universität Darmstadt, near Frankfurt. "I devised bi-criterion optimization solutions for a new type of electricity generator in wind turbines. It wasn't off-the-shelf – it had to be calibrated for each location. We had to determine the parameters - size, diameter, number of magnets in the generators – so we could optimize efficiency and weight, which are conflicting objectives." She then extended the method to deal with more than two objectives, and it was used by a major wind power company.

She said she couldn't have done her PhD on transportation optimization problems at the University of Auckland without an NZIMA scholarship.

She applied bi- and multi-criterion optimization to three different problems. She studied the bi-objective version of the widely-known shortest path road network problem, which "included the safety and suitability of the route. It was fairly theoretical, comparing different algorithms and trying to improve them."

The second was the network flow problem about moving commodities, for example logistics networks through which goods are transported; "there wasn't an algorithm so we proposed one". The third problem was traffic assignment, for example road networks in rush hour, when everyone wants to get to work as quickly as possible. "Planners use these algorithms to see the impact of a new road on traffic patterns."

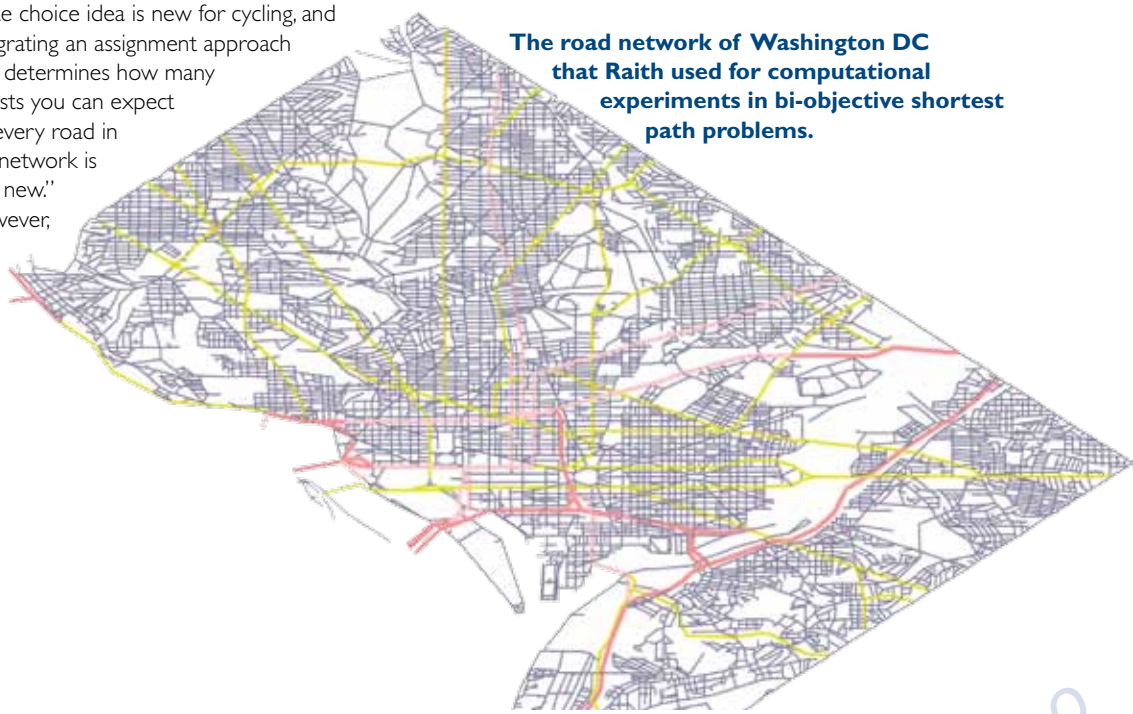
"They usually assume that people travel on the shortest route, and use a generalized cost function that converts time into cost and combines it with other vehicle costs. But it's not realistic - people choose different routes because of convenience or different objectives. With a toll road, for example, some people will use it because it's quicker, while others will always go the long way to avoid the toll. We came up with one algorithm and different ways of dealing with those objectives."

She and her two PhD supervisors, Matthias Ehrgott and Judith Wang, were awarded a Marsden grant to find better ways of solving this multi-objective traffic assignment problem.

She is involved in a project applying a similar theory to Auckland's cycling network. "Cyclists want to minimize their time and maximize the suitability of the path - this includes 20 factors, such as road gradient, traffic volume and speed, road surface and width, combined into a score."

She found that new cycling paths are often decided on in isolation, rather than on how they fit into routes that people want to follow. "We thought it was important to capture that. The route choice idea is new for cycling, and integrating an assignment approach that determines how many cyclists you can expect on every road in the network is also new." However, convincing, or even contacting the Council decision-makers isn't so easy.

She's also using optimization to manage water assets and solve factory production problems. "That's the interesting part of the job - you can link with the real world and help them solve problems."



The road network of Washington DC that Raith used for computational experiments in bi-objective shortest path problems.

$$\forall w \in W, \forall r, s \in R_w \; C_s(f^*) \geq C_r(f^*) \Rightarrow f^*_s = 0$$