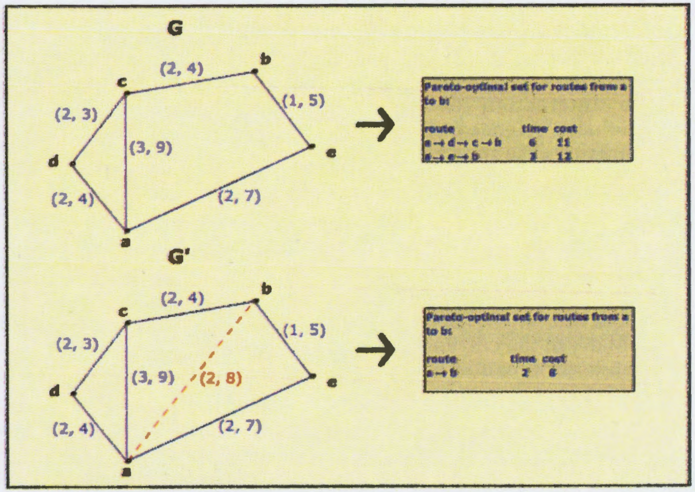
When is the next bus?

Public transport improvement is an important issue in modern cities. New rail systems, bus corridors, privatisation and competition are innovations that require good design for efficiency and usability. Research into journey planning systems and transport network design in the Department of Computer Science at NUI Maynooth is aimed at improving these.

The process of planning a journey by public transport may not be straightforward when one is presented with several alternate routes with associated journey times, fares and numbers of vehicle changes (for example, bus to train) as well as other costs. Ideally, a user of the public transport system would like to choose a journey route with the best values for all these factors, but this is not as simple as it may seem. They all cannot be condensed into one, as trade-offs exist between them. For example, seeking cheaper fares may result in using a route with longer journey times. Also, there may be no solution that contains the best values for all criteria. *Multiobjective Optimisation* can be used to solve this type of problem.

Attempts to narrow down the multitude of alternative routes to a more manageable list can be based on techniques developed by the 19th century Italian engineer-economist Vilfredo Pareto. A computer can use this process to extract a set (known as the *Pareto-optimal* set) of candidate journeys that have no solutions better on all criteria (time, cost, changes). Users then choose their desired journey from this set. The user's task changes from solution finding to choosing, according to their preferences, from the small number of best solutions.

This method based on *Pareto-optimality* can be extended to analyze the 'quality' of public transport networks. Providing a universally acceptable definition of 'quality' for a transport network is difficult, but some of the contributing factors are quite evident, such as average distance to nearest bus-stop, waiting time, journey times and so on. Given an existing network, random additions (mutations) are made to it. Its Pareto-optimal set is re-



An example showing how random additions may produce better routes.

computed. Further analysis of the mutated graph's Pareto-optimal set, combined with comparisons between the two graphs, can be used to decide whether or not the mutated network is more efficient for journey planning.

This procedure is repeated many times, forming a *multi-objective genetic algorithm* that evolves better networks. This technique can be used to suggest changes to, for example, an existing bus network to improve the service. It can also expand to evolve designs for public transport networks from scratch with very little starting information.

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