Technology Strategy Board
Driving Innovation

Knowledge Transfer Network

Industrial Mathematics

Don't be late

OPTIMAL TRIP PLANNING IN THE PRESENCE OF RANDOM DELAYS

BT / University of Birmingham

The need

To determine the quickest route between two points in a timetabled transport network is easy with standard algorithms if the vehicles can be assumed to adhere to the timetable. This is not the case with trains. Recent work at BT allows very accurate modelling of the delays with respect to the timetable. This project would develop new route-planning algorithms which take account of this known delay distribution.

The ultimate aim would be a better website for buying train tickets. But at the first stage, the work was to find the solution of a combinatorial optimisation problem.

The outcomes

The project has provided train passengers a better way to plan their journey; it will provide the best route and the best starting time for their journey and passengers will know that they will arrive at their destination on time even when the trains are delayed during part of the journey. Passengers will no longer need to worry about being late and they will not need to start their journey too early to compensate for the possible delay.

At the end of this project, BT were able to develop a programme which can be used internally by their staff when they need to travel. Ideally, this programme will be used by a public transport company, for example National Rail, to improve their journey planning system on their website.

BT were also able to obtain some new results in generalised order statistics and they have developed ways to decrease the number of calculations required in a problem with exponential computational complexity.

"This was an ideal internship project, combining rigorous mathematics and statistical modelling with a problem of genuine practical interest. To write a programme for the problem which is sufficiently fast is quite a challenge… This was achieved by some clever programming."

Keith Briggs, BT

Technical summary

First it was assumed that the departure times of any two trains are statistically independent and the order of the departure for any two trains may vary due to delay. Most importantly, it was assumed that the passengers will always catch the first train that departs to their next station on their route after they arrive at the station. Data for the train delays were found by comparing the actual departure times of the trains from different stations with the departure time scheduled on the timetable.

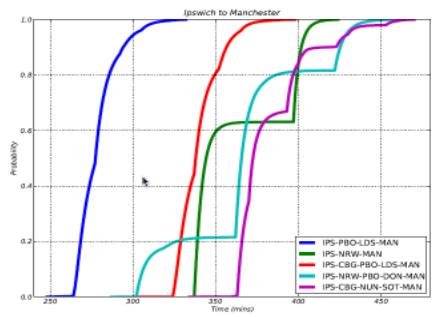
Using the above assumptions and the data collected for the train delays, the intern modelled the train delay for different stations as a probability distribution function. From these distributions and with any given starting time, a method of calculating the time a passenger would take to travel between two stations was developed. From this the probability that the passenger will arrive on time at their destination can be calculated.

Finally, using the method we developed and together with a bisection method, the latest time the passenger can start the trip given the time the passenger wants to arrive at the destination can be calculated given the probability the passenger wants to arrive on time.

For example, if the passenger wished to arrive in Manchester (travelling from Ipswich) before 3pm with a 99% probability, the programme will calculate which train(s) he/she should take and at what time he/she should leave.

A programme (in Python and C) was written for the algorithm and it was tested by considering several journeys, each with several routes. For each route, real train timetables were used to find the best route and starting time for each journey.

CDF for journey times from Ipswich to Manchester



"I was able to gain valuable knowledge and experiences, which I believe are not only useful for my PhD study, but also provide me an excellent insight into the work involved in this [area]. I was also able to learn the programming languages Python and C…"

Peter Tam, University of Birmingham

"This internship was a great opportunity for my PhD student to experience practical applications of knowledge gained during his study. It will be invaluable when he becomes involved with real-life applications after his PhD ... Great experience to be recommended to any research student in Applied Mathematics."

Peter Butkovic, University of Birmingham

This project was part of the programme of industrial mathematics internships managed by the Knowledge Transfer Network (KTN) for Industrial Mathematics. The KTN works to exploit mathematics as an engine for innovation. It is supported by the Technology Strategy Board, in its role as the UK's national innovation agency, and the Engineering and Physical Sciences Research Council, in its role as the main UK government agency for funding research and training in engineering and the physical sciences.

EPSRC
Engineering and Physical Sciences Research Council

Project Details

Partners
BT
University of Birmingham

Project investment
£8,000

Intern
Peter Tam

For further details on the technology:
Keith Briggs
BT
keith.briggs@bt.com

For further information on internships and other collaborations:
Lorcán Mac Manus
Industrial Mathematics KTN
lbmm@industrialmaths.net
+44 (0) 1483 579108