Travel planning in the Multimodal Network of Budapest

Summary

Decisions in the development of transportation infrastructure, and the scheduling of public transport are made with the goal of creating an effective system that delivers passengers to their destination in a convenient and timely manner. We have created a model that simulates passenger behavior in such systems, which can support decision making in these questions.

The problem

The challenges in the project were two-fold: building a suitable model, and developing the necessary algorithms. The model has to be sufficiently detailed, yet manageable in size, so the algorithms finish in suitable time. The algorithms should be ready to accommodate the various needs of the passengers: the modes of transportation available to them, and some objectively quantifiable behavioral rules, like the number of changes in transportation modes they are willing to make. The model also has to account for variations in subjective preferences by generating multiple near-optimal travel paths, amongst which passengers will be distributed.

Results and achievements

As part of the INTCO project (INTegration framework for the economiCal Optimization of mobility and transportation) - a subproject of the EIT ICT Labs' "AIMS Multimodal Mobility" - we worked with the the Department of Networked Systems and Services of BUTE.

The basis of the underlying network is the OpenStreetMap project [1], which is a community-driven free map. At its core, it is a collection of physical features marked up with tags describing various features. A software was developed for retrieving and cleaning the data relevant to our project. The timetable data for the public transportation network is obtained from the Centre for Budapest Transport (BKK) in GTFS format [2]. This data was cleaned and matched up with the existing physical network to create a multi-layered network model.

The availability of Open Street Map and the General Transit Feed Specification for other cities make this approach easily transportable to other cities.

Computing the shortest path for a given input (origin, destination, time of departure, and user preferences) was done using the time-dependent version of Dijkstra's algorithm. Alternative paths are then generated by using the first-deviation approach (see e.g. [3]).

These paths are mathematically different, but not "sufficiently distinct", as a second shortest path might be the same as the first one, except for a short detour in the walking part of the path, or might take the same bus that arrives 3 minutes later.

Modeling such a subjective notion is inherently difficult. One solution is identifying the "pattern" of a solution (e.g: walk – bus 7 – walk – metro 3 – walk), and discarding solutions that match the pattern of a previous solution.

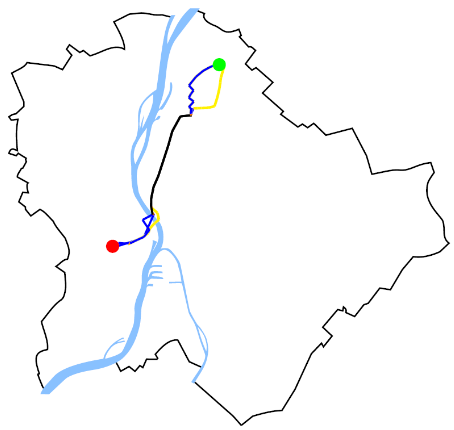

Figure 1: Alternative shortest paths

Another way to simplify this problem is to consider only the number of vehicles used as a secondary objective. Such multiobjective optimization problems are hard generally, but in this case the secondary objective takes discrete values. In other words, if there is a path that minimizes time, but uses 4 transfers, then we are further interested in paths only if they use at most 3 transfers, and so on. Ultimately getting at most 5 paths, each being the shortest one with at most 0, 1, 2, 3, and 4 transfers. These solutions are called "Pareto-efficient" regarding the two objectives. Computing these paths can be done without actually solving 5 different problems, by slightly modifying the algorithm used before.

Finally, a visual representation of the paths found can be generated automatically.

Contacts, references

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[1] OpenStreetMap project:
http://www.openstreetmap.org/about

[2] General Transit Feed Specification:
https://developers.google.com/transit/gtfs

[3] S. E. Dreyfus: An appraisal of some shortest-path algorithms. *Operations Research*, **17** (1969), pp. 395–412.