A Line Planning Model for Delay Resistance

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Abstract

In modern public transportation networks, delays are the main issue for disturbing smooth operations and hence the dissatisfaction of passengers. Thus, it is crucial for the operators to know how to deal with delays in a sophisticated way.

Until now the delay resistance of public transportation networks was widely viewed as a problem that had to be incorporated by planning robust timetables. The idea of robust timetables is to add security buffers. However, increasing buffer times in the timetables immediately leads to higher traveling times for the passengers. We hence have a trade-off between the planned and the actual traveling times. Thus, the passengers either have to endure additional buffer times when no delay occurs or suffer from the delay if not enough buffer times are added.

Our novel approach tries to work around this problem by tackling the issue of delays even before the timetable is planned. The aim is to develop a line concept that leads to delay resistant timetables. When viewed from the stage of line planning, which factors impose delay resistance?

A main factor for propagation of delays are passengers' transfers. Trains that wait for delayed passengers get themselves delayed and hence carry on the delay into the network. The idea is to design lines in a way that the number of transfers over all passengers is minimized. In this new model it is necessary to determine not only the lines but also the paths for the passengers. Additionally, it has to be ensured that all passengers can travel according to their wishes.

In order to find line plans with a minimal number of changes, an integer program is proposed. However, on realistic networks the number of possible paths and thus the number of variables is huge. Hence, our approach for solving such problems is via column generation. The method is embedded into the LinTim framework which facilitates the evaluation and comparison of solution characteristics using close-to-real world data. Furthermore, LinTim takes care of solving the problems resulting from later planning stages.

Having planned the lines and the timetable, the decisions to be taken in the delay management problem is to decide which transfers to maintain. Solving this problem is hard, but is enhanced by only having a small number of decisions to be taken at all. Thus, the new line planning model can, therefore, be viewed in an integrated perspective with delay management and timetabling.