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Practical macroscopic evaluation and comparison of railway timetables

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Abstract

From the perspective of passengers, a railway timetable can be called better than another if its expected passenger time is lower in practice. So, we constructed an analytical function that evaluates a timetable on this criterion: total expected passenger time in practice. Other methods to evaluate timetables invariably describe different performance indicators: realisability, conflict-freeness, stability, efficiency, robustness, resilience, but mostly do not indicate how to score and weigh these different performance indicators. This means that when comparing two timetables, deciding which one is preferable remains hard. Our objective of expected passenger time in practice resolves these issues.

Also, compared to a simulation approach, our analytical stochastic approach has a major practical advantage. It decouples all actions (ride, dwell, transfer, knock-on) in the timetable and in doing so, can evaluate the expected time in every action separately and simply add all expected times of composing actions afterwards. So the exponential amount of combinations of primary delays over all actions that standard simulation packages explicitly iterate over is dealt with implicitly and much more efficiently. This makes that the evaluation made by our method requires less time.

Our method is applied to two timetables of all passenger trains in Belgium. Both timetables were manually planned and then put into operation in practice. With our method, we can conclude that one timetable has considerably lower total expected passenger time in practice than the other one. We also show that this is caused mainly by better passenger transfer planning, but also partly by a changed line planning. Comparison of the reported results for both timetables also suggests that advantages of each could maybe be combined.

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1. Introduction

Whenever a railway company updates or completely overhauls a timetable, it is highly important to evaluate the new timetable and compare it to the previous one, before the new timetable is implemented in practice. Today, evaluation

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methods are typically restricted to simulation methods that do not report expected passenger time but mainly focus on train time, ignoring passenger numbers in ride, dwell and transfer actions and in knock-on delays (Weston et al., 2006; Parbo et al., 2015). More recently, this shortcoming has been remedied by some (Weston et al., 2006; Kanai et al., 2011). Also, often no measuring of positive effects of temporal spreading of alternative trains is present. So these methods do not answer some relevant questions that should be asked when developing and evaluating a new timetable.

Questions to be asked about the correctness of any timetable are: Are all minimum ride, dwell, transfer and headway times respected? Questions about whether the new timetable is an improvement compared to the previous one are: Is total expected passenger time in practice reduced? Is the average probability for passengers of missing transfers reduced? Are secondary delays for passengers diminished?

In this paper, we provide a methodology and a tool to answer all these questions. The output is presented graphically, so that the effects - both in size and in sign - of differences between timetables become more visually obvious. As such, strong and weak points in the new timetable, for example better transfer planning or a worse headway planning, will be noticed quickly. Our method is applied to two different timetables, both of all passenger trains in Belgium and shows that the newer of the two timetables is indeed improved. We believe our tool is innovative in the sense that it shows how much better or worse a timetable is for passengers and on which aspects. It also pinpoints where expected passenger time is spent: during ride, dwell, transfer or knock-on actions. In an early stage, our evaluation method could indicate where to further improve the timetable and in the end it could deliver crucial arguments to convince anyone about the benefits of implementing the new timetable in practice.

Section 2 compares traditional timetable evaluation methods with our approach. Section 3 demonstrates the results of our evaluation approach applied to two manually constructed timetables, T1 and T2 as received from Infrabel, the Belgian infrastructure management company. T2 is a reworked version of T1. Due to confidentiality issues, we cannot give more details about these timetables. Sections 4 and 5 conclude this work and indicate some potential further work.

2. Comparing Timetable Evaluation Methods

Both our quality criterion for and our practical implementation of evaluating timetables are quite different from the traditional criteria and practical methods. So, in this section, we first contrast and compare them. We then show that our approach has quite some theoretical as well as practical advantages and next, explain that we cover most performance indicators present in the traditional approaches.

2.1. Traditional Approach: Estimating Performance Indicators by Simulation, mainly Microscopic

Goverde and Hansen (2013) propose a list of timetable performance indicators and derived quality levels. Widely used terms for these indicators are realisability, conflict-freeness, stability, efficiency, robustness and resilience. We are convinced that these six performance indicators should actually be considered as means to obtain the final goal of serving the passengers in the best possible way. According to us that corresponds to minimising the expected passenger time in practice. The performance indicators realisability and conflict-freeness can be checked by verifying that the minima for ride and dwell respectively for headways are respected. Together, realisability and conflict-freeness could be seen as operational feasibility. So these two criteria are easy to check. Contrary to these, the four other performance indicators depend on primary delays and on how these are propagated in the train network. Because of the stochastic nature of primary delays, timetable evaluation on these criteria is usually done via simulation, where a single simulation randomly takes one sample for each primary delay distribution and then applies these combined delays on the system and propagates them to secondary delays on affected trains. This way, simulations can calculate total delays. As an example, a low total delay then indicates a good robustness against these primary delays. For large networks, to cover all cases or rather to obtain a representative collection of all cases, this means that many simulations have to be performed.

Barber et al. (2007) give a list of available software simulation packages (e.g.: RailSys of RMCon, SIMONE of NS). More recently, quite some more software packages have become available (e.g.: LUKS of ViaCon, and OnTime of TrafIT Solutions & ViaCon). Some packages simulate on the macroscopic or mesoscopic level, but quite some