Public transport reliability: the spatio-temporal accessibility case

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1. Introduction

Transport networks constitute the backbone of urban and regional systems as they provide the required channels for spatial interaction. To that end, an important dimension of transport systems concerns their reliability. In brief, reliability measures have evolved the lines of accounting for the impact of recurring and non-recurring congestion on the performance of the system. Especially for the case of public transport systems, reliability can be seen as an important intrinsic characteristic of the system due to the multi-chain character of the trips, where a potential delay might translate into a subsequent missed connection, and hence a disproportionate travel time increase for the affected users (1). Nevertheless, the majority of developed reliability indicators focus on the supply side of the system, failing to incorporate passengers’ dimension into their formulation (2).

2. Methodology

In this work, we propose an alternative way of evaluating public transport reliability based on the concept of gravity-based accessibility which quantifies the potential for interaction between origins $i$ and destinations $j$. More specifically, the accessibility of origin $i$ is the weighted sum (using travel time $t_{ij}$) of the opportunities $W_j$, $\forall j \in N$, with $N$ denoting the set of interacting locations.

$$\text{Acc}_i(W) = \sum_{j \neq i}^N W_j f(t_{ij})$$ (1)

Travel time varies throughout the day, and, as a result, accessibility varies accordingly. The spatio-temporal variance of public transport accessibility has been acknowledged and investigated in different studies in literature (e.g. (3)).

For each time interval $\tau$, we can define as normative the accessibility levels corresponding to the schedule-based travel times (denoted as $\text{normAcc}^\tau_i$), and as positive the realized ones (denoted as $\text{posAcc}^\tau_i$), in accordance to the definition introduced by (4). Finally, by evaluating the spatio-temporal variance of these two measures jointly, we can

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identify stops of the network that experience unreliable public transport connections (systematically) during the day, or specific periods. In this regard, a relative accessibility indicator (denoted as $RelAcc_i^τ$) is introduced that quantifies the relative percent difference between the normative and positive accessibility levels, in the following manner:

$$RelAcc_i^τ = \frac{100 \times (posAcc_i^τ - normAcc_i^τ)}{normAcc_i^τ}$$  \hspace{1cm} (2)

Ideally, a reliable public transport system should be able to retain relative accessibility levels close to zero, with small variances during the day.

3. Case study - Preliminary results

A case study for the city of Zurich in Switzerland is designed in order to showcase the application of the proposed methodology. More specifically, we utilize publicly available travel time data\(^1\) for a random day in 2018 (January 18\(^{th}\)), where actual travel times are reported.

The population and employment positions within a 200-meter radius from each stop are chosen as the opportunities $W$. Subsequently, the relevant accessibility indicators are calculated for 10-minute time intervals. We focus on the morning (7:30am–9:30am) and afternoon (5:00pm–7:00pm) peak periods, respectively.

In the following figure, the median values of the corresponding relative accessibility indicators for the morning peak period are plotted. As it can be seen, the median relative values in some cases are found to be almost $−25\%$, revealing cases where the actual level of transport service is much worse than the schedule-based one. In conclusion, an apparent advantage of the presented methodology is that it accounts for the system-wide interaction potential, providing an alternative way of incorporating passengers’ dimension into public transport reliability formulations in a straightforward manner. Moreover, it has low data and computational requirements, and, as a consequence, it can be easily adopted by practitioners and public transport authorities.

![Fig. 1: Median relative accessibility values for the morning peak period](https://data.stadt-zuerich.ch/dataset/vbz_fahrzeiten_ogd)

Fig. 1: Median relative accessibility values for the morning peak period

References


\(^1\) [https://data.stadt-zuerich.ch/dataset/vbz_fahrzeiten_ogd](https://data.stadt-zuerich.ch/dataset/vbz_fahrzeiten_ogd)