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Investigating the effects of real-time crowding information (RTCI) systems in urban public transport under different demand conditions

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Introduction

This study present results from simulation analysis of providing real-time crowding information (RTCI) on instantaneous (on-board) crowding levels of public transport (PT) services in urban networks, focusing on possible implications of variable demand responsiveness to such information. In recent years, an increasing emphasis has been put on development of various travel demand management tools and especially advanced traveler information systems (ATIS), which aim to overcome problems associated with ever growing passenger congestion in urban transport systems. Nowadays, a further extension of these systems is highly feasible within the framework of modern-day ITS systems, as passenger flow data collected from various sources – APC and AFC systems, smart-card ticketing systems etc. – can be easily utilized to inform travelers about the current passenger flows, i.e. real-time loading levels of public transport vehicles (the so-called RTCI system). However, such systems are still in early development stages and substantial research gaps still remain with respect to – among others – effective information provision strategies, as well as implications of RTCI systems upon PT system performance under various network conditions (scenarios). It is conceivable that instantaneous crowding information may not always be fully efficient due to possible system "over-reaction" in certain circumstances. Furthermore, a key challenge is how to ensure the crowding advice accuracy for PT users – more research insight is badly needed to understand whether the RTCI credibility might be fully sustained in real-time conditions without employing complex information processing (e.g. predictive) mechanisms and algorithms.

Method and preliminary results

For the purposes of this study, we utilize the the dynamic, simulation-based transit assignment model incorporated in the BusMezzo software [1]. The BusMezzo model assumes a detailed representation of both supply and demand sides of the PT system and their mutual interactions – especially, explicit representation of passenger congestion-induced phenomena. Crucially, the path choice algorithm allows to replicate the dynamic and sequential properties of passengers' decision-making patterns, and the possibility to reconsider their travel choices en-route with access to real-time travel information. To replicate the passengers' travel behaviour in the event of instantaneous access to RTCI, we utilise the extension of BusMezzo path choice algorithm [2] which addresses the following key steps of evaluating and disseminating the crowding information:

- Firstly, the observed RTCI is calculated (recorded) at each exit instance of PT vehicle (run) from a given stop – i.e. for each individual run ("stop-to-stop") segment. The observed RTCI is a function of the on-board volume-to-capacity ratio and is evaluated analogous to travel time valuations due to PT crowding, as commonly reported in research studies [6], [7], [8].
- Secondly, the generated RTCI is calculated (updated) for each individual PT line segment at each instance a new PT vehicle (run) traverses that particular segment (fig. 1). Here, we assume that generated RTCI is evaluated in an "instantaneous" manner, i.e. in direct reference to the observed

RTCI of the latest run only (i.e. being simply "overwritten"). Additionally, the RTCI can be generated as an exponentially smoothed average of multiple runs (i.e. update to the previously stored RTCI value for a certain line segment).

RTCI level	in-vehicle occupancy level	crowding penalty $\beta^{RTCI}_{l,e}$
●○○○	< 80% seat capacity	**1.0**
●●○○	≤ 100% seat capacity	**1.2**
●●●○	< 80% total capacity	**1.5**
●●●●	≤ 100% total capacity	**1.8**

Fig. 1. The assumed RTCI "mapping" framework: in-vehicle travel time multipliers corresponding to the recorded (observed) on-board crowding conditions.

- Finally, the RTCI anticipated by travelers is included as an in-vehicle travel time multiplier of each individual line ("stop-to-stop") segment and is equal to the latest available RTCI value stored for that particular segment – i.e. valid at the time when passenger is making a travel decision. The traveler then chooses among the available travel actions (alternatives), considered in his (her) choice set, according to probability as evaluated by the generic (MNL) discrete choice model implemented in BusMezzo [1].

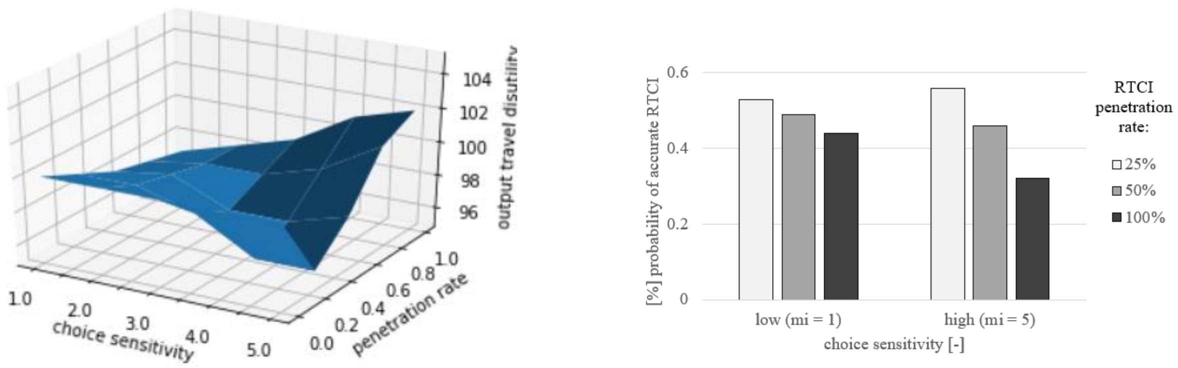

Fig. 2. Preliminary results from simulation works on sample PT network: output system performance (travel disutility) measured with respect to input demand characteristics (left) and resultant accuracy of provided RTCI (right).

The proposed modelling framework is then simulated on sample PT networks, where evaluation of assignment output is formulated as a 3-dimensional problem (fig. 2, left). We observe how the passenger welfare (vertical axis), i.e. output measure of PT system performance, correlates with 2 crucial input demand characteristics related to crowding information systems (horizontal axes): choice sensitivity and penetration rate of RTCI. It could be expected that combination of these 2 properties forms a certain "trade-off" determining the overall efficiency of RTCI system for passengers: as choice sensitivity evolves towards more deterministic model (i.e. rising sensitivity parameter), the outcome of ubiquitous RTCI availability becomes counter-productive for passengers, as measured both by output welfare changes (fig. 2, left) and deterioration in crowding information accuracy (fig. 2, right) – though this can be apparently prevented by limiting the share of passengers following the RTCI in their decision-making process. This detrimental effect is less pronounced in probabilistic choice scenarios, where lower choice sensitivity implies that RTCI has relatively lower impact upon resultant choices, but improvements in PT travel experience might be achievable even with a major share of travelers observing the RTCI.

Summary and contribution

The objective of our work would be to shed more light upon changes in PT system performance which might arise in conjunction with launching the future real-time crowding information (RTCI) systems. Findings presented in this study will help better understand how instantaneous RTCI provision might affect output passengers' travel experience under different demand responsiveness scenarios. Simulation results will also whether the "robustness" of instantaneous RTCI accuracy would hold true in variable demand settings, indicating the potential need for employing more advanced information evaluation algorithms (e.g. shifting towards predictive crowding advice) or dissemination strategies. We hope that observations presented in our work will provide a useful contribution for future development of real-time crowding information systems in PT networks, both of academic relevance and in terms of their practical implementation.

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