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Dynamic routing on transit networks with both schedule-based and frequency-based services

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Abstract

This article introduces a unified framework for the computation of dynamic shortest paths and hyperpaths on transit networks, where passengers optimize their route choice based on the available information about service performances and reliability.

The proposed methodology can be applied in the context of dynamic transit assignment, as well as in the context of point-to-point navigation for passenger trips.

In particular, the algorithm implemented in the journey planner HyperPath (www.sistemaits.com) is presented as a convenient specification which allows to address the case of mixed transit services with both schedule-based and frequency-based lines.

Keywords: dynamic shortest hyperpaths, dynamic transit assignment, journey planning, real-time updates of the programmed schedule.

Introduction

The vast majority of the literature regarding shortest path search addresses the classical static case, where the problem is to find the cheapest route connecting the origin node to a destination node on

a graph with given arc costs that are constant in time.

Instead, there are not so many contributions addressing the more realistic situation where network performances vary during the day, so that every arc must be associated to a temporal profile of the link travel cost which does not coincide in general with the temporal profile of the link travel time. Besides being a major cost component, travel times are indeed important to properly take into account the entry instant of the user on each arc of the path and then evaluate the actual cost perceived during the trip.

It is known that dynamic case can be reduced in principle to an application of static solution approaches to a space-time network (Pallottino and Scutella, 1998). However there are several circumstances that let this more general instance of the problem deserve specific attention and consideration. This is particularly true if we refer to large transport networks, where we may be willing to pay a small price in terms of generality to gain efficiency in the computation.

In this paper, we address the specific case of public transport networks, where the service provided by transit lines is intrinsically discontinuous in time.

Two behavioural approaches of how passengers perceive the service can be considered to represent transit lines: frequency based and scheduled based. In the first case, the arrival of transit carriers at the stop are so frequent or so irregular/unreliable that the passengers finds no convenience in timing his/her arrival to the stop with the line schedule, which is instead considered in the second case. In the frequency based approach the routing problem becomes the search for an optimal strategy which can be represented through an hyperpath (Pallottino and Nguyen, 1998) considering the fact that passengers wait at stops for the first carrier belonging to a set of attractive lines. In Gentile et al. (2005) we analyzed the effects of information on the carrier arrivals provided at stops to passengers combined with different headway distributions. In Trozzi et al. (2013) we addressed the delicate issue of how the stop layout can affect queuing and boarding strategies in a dynamic context.

On the supply side, however, the transit service is anyhow typically operated as a sequence of runs for each line with a given departure times and instants of (possibly estimated) passage at stops, here referred to as the *programmed schedule*, even if on some transport system (e.g. urban busses) its daily realization may be affected by a high variance. The above consideration lead us to the idea that a unified modelling framework can be easily developed if the programmed schedule of all runs is used also to compute the line headway at each transit stop and the on-board speed of each route section at different times of the day, which are needed for the frequency based approach.

The main aim of this paper is then to present a new dynamic rooting algorithm which allows to address the case of mixed transit services with both schedule-based and frequency-based on large real networks where this two kind of perceived facilities often coexist. This algorithm is actually implemented in the journey planner HyperPath (www.sistemaits.com - PTV Group).

An application to the metropolitan area of Rome is presented, where the availability of real-time information about the forecasted arrival times of specific runs at transit stops, provided by the AVL system, allows to update the programmed schedule used in the computation of routing solutions requested on-line by passengers, also via smartphones.

References

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