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A Multi-Modal Routing Approach Combining Dynamic Ride-Sharing and Public Transport

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Abstract

Ride-sharing facilitates cheap and eco-friendly mobility. In contrast to classical ride-sharing that basically works like a notice-board, dynamic ride-sharing allows a passenger to get a lift on a section of a driver's route and, if necessary, re-routes the driver. On a dynamic ride-sharing platform, drivers provide their routes and passengers specify queries consisting of departure and arrival location as well as a time for the journey. The platform computes suitable matches of driver routes and passenger queries, and proposes them to both parties.

State-of-the-Art platforms for public transport routing and dynamic ride-sharing provide unimodal connections but do not combine both transport modes. The challenge is that the driver routes are not static but could be changed significantly if the driver accepts the detour to pick up the passenger and drop him / her off at his / her destination. Thus, a driver's route may result in a number of dynamic ride-sharing offers, namely all possible connections between pick up and drop off points with an acceptable detour for the driver. In this paper, we present a solution that integrates dynamic ride-sharing into our existing multi-criteria intermodal travel information system. We solve two challenges: First, we allow dynamic ride-sharing between two train rides by connecting public transport stations by dynamic ride-sharing offers of drivers. For this, we integrate driver offers into our graph model, which represents the public transport timetable. Second, we find suitable dynamic ride-sharing offers of drivers who can take the passenger from his / her start location to a public transport station or from a station to the queried destination location. In our computational study, compared to unimodal train connections, we obtain a significant improvement of the results by combining public transport and dynamic ride-sharing.

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Keywords: Dynamic Ride-Sharing, Intermodal Travel Information, Graph Algorithms, Pareto Optimal Search, Multi Criteria

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1. Introduction

The algorithms group at the department of computer science of Technische Universität Darmstadt has a long track record in developing multi-criteria timetable information systems (Müller-Hannemann et al., 2002 and 2007, Disser et al., 2008). Since 2008 our systems are capable of incorporating real time information. This allows us to support the traveler in case of delays (Frede et al., 2008). Current research focuses on intermodal travel information systems incorporating public as well as private transportation (Gündling et al.,2014).

1.1 Motivation

Current and future mobility requirements demand intelligent solutions. Ride-sharing is gaining in importance, and yields benefits compared to costly, eco-unfriendly individual car rides. Dynamic ride-sharing makes better use of existing resources by bringing travelers with matching routes together. Participating drivers and passengers can be matched on-demand or in advance. This is done by calculating the detour required for the driver to give the respective potential passenger a lift. If the result matches certain criteria, both the driver and the potential passenger receive an offer and decide whether to accept or decline.

Our existing multi-modal routing system computes door-to-door connections by incorporating public and private transportation. It optimizes the criteria travel duration and number of train and mode changes while the price is also taken into account. In this work, we present an approach to fulfill future individual traffic demands by proposing a journey information system, which adds dynamic ride-sharing to our routing system.

The motivation is that both these modes are complementary: On the one hand, public transport is quite sparse in some regions, but dynamic ride-sharing offers to reach areas with limited public transport connectivity. On the other hand, the number of dynamic ride-sharing offers relevant for a query increases when allowing routes which bring the passenger to a station where he can continue his journey using public transport.

This way, dynamic ride-sharing as well as public transportation benefit from this combination: by offering dynamic ride-sharing to travelers using public transportation, the car utilization can be improved (reducing costs for the driver). Furthermore, the result quality of timetable information systems can be enhanced by additional optimal connections which use dynamic ride-sharing.

1.2 Our contribution

In this work, we address two problems to combine dynamic ride-sharing and public transport: connecting public transport stations by dynamic ride-sharing connections and connecting start and destination of a query to public transport stations by dynamic ride-sharing routes. To solve the first challenge we add station-to-station connections that are derived from dynamic ride-sharing offers to our graph representation in a preprocessing step. These connections can be updated when matches are agreed upon, offers are withdrawn, or new ones are available. The second challenge requires the selection of suitable ride-sharing offers that allow for a connection from the start location to a station or from a station to the destination location. Since the source and destination address are given in the individual queries and are not known beforehand, in contrast to the set of stations, this step needs to be carried out on-the-fly for each query.

1.3 State of the Art

In the literature different multi-modal search algorithms combining public and private transportation have been described, see the recent survey (Bast et al., 2015). There are also commercial systems available[2] . To the best of our knowledge neither of these find optimal connections combining public transport and dynamic ride-sharing.

[2] Such as http://www.fromatob.de/ and https://www.qixxit.de/en/