Exploration of ride-sharing opportunity at the TUM Garching campus

Master Thesis: Lukas Mohs

Abstract

Modern automobile transportation is facing a great transition driven by the development of self-driving vehicles, electric cars and carpooling systems. Within the proposed thesis, the potential of a commuter platform will be elaborated that matches travelers of similar routes into joint trips. First, the underlying matching problem will be formalized by focusing on the choice of variables and objectives. This model is enhanced and discussed using empirical data retrieved from commuters to the campus of Technical University Munich (TUM) in Garching, Germany. Further investigations about previous studies and coexisting solutions are then aggregated in order to derive core implications for the development of a commuter matching platform. Based on these studies, the software will be designed and implemented as well as validated against a simulated user base.

Background

The Commuter Matching Problem

The majority of vehicles in Germany have a capacity of five seats, but only 1.5 of them are used on an average trip. Commute rides to work don't even exceed a capacity of 1.2 passengers on average [35]. Concluding this, one can identify the high potential of increasing the utility of the vehicles as well as of the automobile infrastructure. When matching commuters, the total distance driven should be reduced. Meanwhile the total travel time and required flexibility shouldn't be increased to much. Further, matching might include user characteristics and preferences.

Platform Development

The advent of platforms in the IT domain during the last years emphasized an important social and economic impact in many fields of industry. The platform as a business model creates a standalone market, which connects providers and customers and is controlled by an operator. Design principles, policies and the growth strategy form decisive factors which have to be studied and identified for each environment individually.

Motivation

On average, there are 668 vehicles per 1000 inhabitants in Germany and the number is constantly increasing. At the same time, the impact of congestion is rising especially in metropolitan areas, where many commuters travel from outer regions into city centers or business parks.

A successful match results is a win-win situation since the passenger reduces fuel consumption, mileage and driving effort. Additionally, the driver can split his fare with passengers or form a commuter group in order to alternate the role of the driver. Finally, a company or institution might also be in favor of the successful match since many cars are leased by the company and an increased exchange between employees supports the company's network effect.

The concept of car sharing also claimed its first success in some big cities, which proofs a general emergence of the Share Economy and a broad environmental awareness.

Research Question

1. What are the existing strategies and approaches to solve real-time ride-sharing?
2. How to formalize the commuter matching problem in metropolitan areas?
3. How to design and implement a platform for daily ride-sharing in metropolitan areas?

Literature Overview

The first practical organized carpooling studies have been undertaken in Bellevue and Seattle in Washington as well as Sacramento, Coachella and Los Angeles in California during the 1990s [17]. These similar systems were introduced to take advantage of the so-called "high-occupancy vehicle" (HOV) lanes on several highways, which permit just vehicles with more than one passenger driving on a specific lane. Besides empirical studies about the participants, functionality, usability and the payment system, social aspects were researched, too [2,4,5,6,7,8,10,11,12,13,14,15, 17,18,19,20,21,22,23,25,26 ,28,29,30,32]. Further studies discussed the potential for ridesharing for single universities or companies [9,24,27,31]. Hwang and Giuliano analyzed the travel distance, parking options and company size [22]. The master thesis of Andrew M. Amey (MIT) particularly emphasized the importance of incentives for travelers and potential strategies for reaching a critical mass when establishing a commuter system to the MIT campus [17].

In a report of the University of Maryland, the "Real-time Rideshare Matching Problem" is treated by analyzing and comparing state-of-the-art systems and furthermore formalizing the theoretical model. This model included smoking habits, pet friendliness together with gender and age preference into one trip matching function [3].

In 1981, there was the first organized commuting system in Germany operated by the city of Friedrichshafen, which was based on a shared taxi system of predefined route points [17,18]

Another system called "M21" was established in 1998 and operated by Daimler-Chrysler and the State of Baden-Württemberg with the goal of increasing the car utility of commute rides to the company's research facility [16, 17].

Since 2010, "Flinc" provides a matching platform for spontaneous short-distance trips and daily commuting routes in Germany [3,27,33,34].

Methods

Modelling of Optimization Problems

By formalizing the commuter matching problem as a combinatorial optimization problem, the theoretical foundation for the algorithm can be laid that identifies the best matching solution out of the set of all feasible solutions. In Addition to the best theoretical solution one has to adapt the matching procedure to two aspects: the dynamic nature of trip assignments as well as the selfish behavior of all agents.

Empirical Research

To exemplary study the market segment of students and faculty commuters, empirical methods will be applied. A quantitative study will be based on survey data and analyzed to describe the behavior and attitude of this potential customer group. Furthermore, adjustments of the modelled problem could be undertaken based on the identified valuation of time and travel costs.

Descriptive Research

The descriptive research analyzes previous and the state-of-the art solutions to solve ride-sharing in other countries including the given circumstances. Further, market competitors in Germany are studied regarding their matching approach and technology. From this analysis, major requirements for platforms in that segment will be visible.

Software Engineering

As part of the Software Engineering process, which will be used to create the commuter matching platform, subdisciplines like requirements engineering, software design and testing will be dealt with. In particular, personas and their specific use cases will be defined, the platform architecture will be modelled and afterwards implemented. Finally, the matching functionality will be tested by simulating several simultaneous platform users.

References

#	Title	Type	Year	Author
2	Smart peer car pooling system	Paper	2016	Middle East University (Oman)
3	Real-Time Rideshare Matching Problem	Paper	2011	University of Maryland
4	Ridesharing in North America: Past, Present, and Future	Paper	2012	University of California, Berkeley
5	Casual carpooling in the San Francisco Bay Area	Article (Magazine)	1990	Transportation Foundation
6	Impacts of Employer-Based Trip Reduction Programs and Vanpools on Passenger Vehicle Use and Greenhouse Gas Emissions	Paper	2014	University of Southern California
7	WHAT MAKES A CAR-SHARER?	Paper	1984	The University, Leeds'
8	Ridematching Online: An Evolution in Service Delivery	Article	2004	Association for Commuter Transportation
9	EMPLOYEE TRIP REDUCTION IN SOUTHERN CALIFORNIA: FIRST YEAR RESULTS	Paper	1993	UCLA
10	Commute trip reduction—a collaborative approach	Paper	1999	Department of Transportation
11	Slugging in Houston — Casual Carpool Passenger Characteristics	Paper	2006	A&M University
12	A distributed geographic information system for the daily car pooling problem	Paper	2004	Universit e de Technologie de Troyes, University de Ferrera, University de Bologna
13	Seattle smart traveler: dynamic ridematching on the World Wide Web	Paper	1999	University of Washington
14	COMMUTER CONNECTION: FLEXIBLE RIDESHARING IN MARIN COUNTY, CALIFORNIA	Paper	1981	Washington, DC: Urban Mass Transit Administration
15	The rise and fall of the American carpool: 1970–1990	Paper	1997	Erik T. Ferguson & Associates

16	STUTTGART: M21 - a telematics-based mobility service for commuter traffic	Article	2001	DAIMLER, Baden-Württemberg
17	Real-Time Ridesharing: Exploring the Opportunities and Challenges of Designing a Technology-based Rideshare Trial for the MIT Community	Master Thesis	2010	MIT
18	Flexible Operation Command & Control System (FOCCS) With Vehicle-Autonomous Schedule Control and Synchronisation	Paper	1992	Rufbus GmbH
19	Advanced Public Transportation Systems: The state of the Art	Report / Book	2000	Federal Transit Administration, Washington
20	Bellevue Smart Traveler: Design Demonstation and Assesment	Report	1995	Federal Transit Administration, Washington
21	Los Angeles Smart Traveler Field Operational Test Evaluation	Report	1995	University of Southern California, Berkeley
22	. The Determinants of Ridesharing: A Literature Review.	Working Paper	1990	University of California Transportation Center
23	Casual Carpooling—Enhanced	Article	2007	Association for Commuter Transportation
24	Travelling to work: will people move out of their cars	Paper	2001	University of Hertfordshire
25	Real-Time Ridesharing Opportunities and Challenges in Using Mobile Phone Technology to Improve Rideshare Services	Article		MIT
26	Rideshare History & Statistics	Website	2009	MIT
27	Flinc - Mobilitätsmanagement und die Förderung von Fahrgemeinschaften im Unternehmen	Studie	2012	Flinc, Rheinland-Pfalz
28	Evaluation of Springfield Instant Carpooling	Paper	1989	The Urban Institute
29	RideNow Casual Car Pool	Website	2015	
30	Vanpool Pricing and Financing Guide	Paper	2000	University of South Florida
31	Zimride	Website		
32	Dynamic ridesharing and information and communications technology: past, present and future prospects	Article	2011	University of Toronto at Mississauga
33	Optimization for dynamic ride-sharing: A review	Paper	2012	Erasmus University, Georgia Tech, Newcastle (AUS)
34	Investigating ride sharing opportunities through mobility data analysis	Paper		University of Modena and Reggio Emilia, Italy