Master Thesis Kickoff – Exploration of Ride-sharing Opportunities at the TUM Garching Campus

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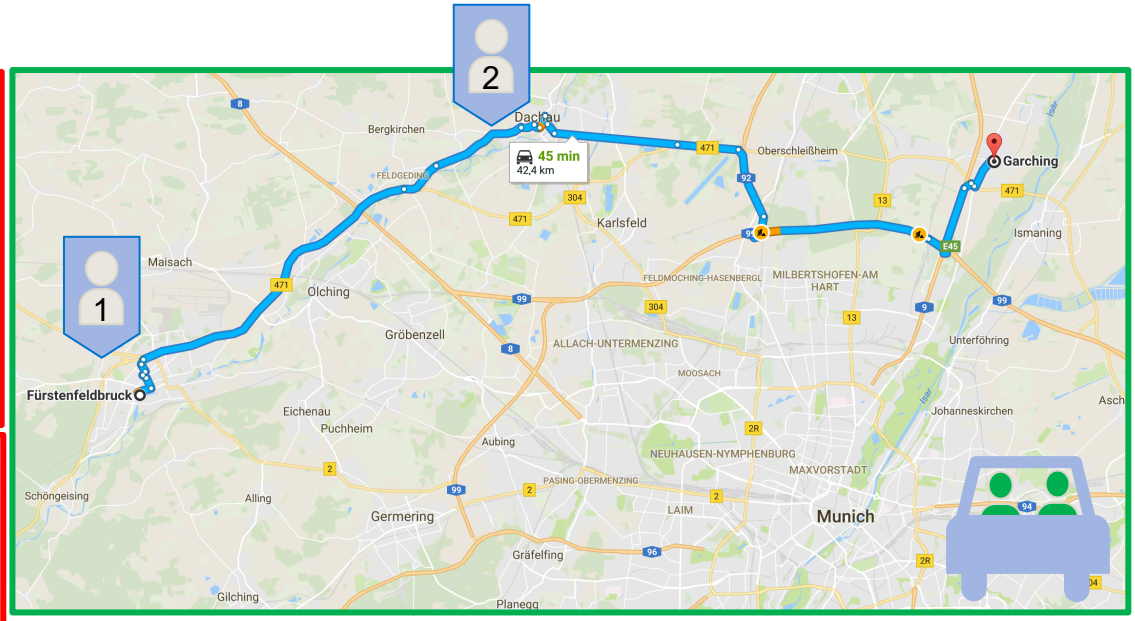
Outline

1. Introduction / Motivation
2. Research Questions
3. Methods
    1. State-of-the-art Analysis
    2. Empirical Research
    3. Modeling as Optimization Problem
    4. Software Implementation and Evaluation
4. Rough Timeline
5. Questions / Feedback

Introduction

- “Ride-sharing” == “Carpooling”
  - != “Carsharing” (*DriveNow*)
  - != “Transportation Service” (*Uber*)
  - != “Long-distance Carpooling” (*BlaBlaCar*) [1]
- Real-time (dynamic) vs. pre-organized



[1] https://www.blablacar.com/

Motivation

- The impact of congestion is rising in metropolitan areas
- Commuters travel from outer regions into city centers or business parks

- The majority of vehicles in Germany have a capacity of 5 seatss
  - 1.5 of them are used on an average trip [2]
  - Commute rides to work: 1.2 passengers on average [2]

- A matching platform for commuters creates win-win-win situation:
  - ✓ Passengers can save travel time
  - ✓ Drivers can split the fare and might share their driving effort
  - ✓ Institutions / companies benefit from decreased infrastructure and car usage as well as from networking effect between passengers

[2] Mobilität in Deutschland, Bundesministerium 2008

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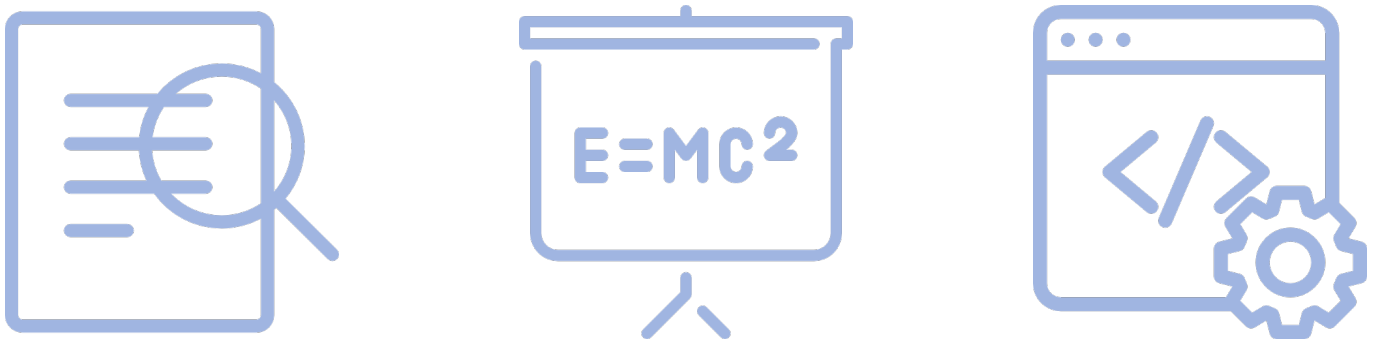
Research Questions

1. What are the existing strategies and approaches to solve real-time ride-sharing?

2. How to formalize the commuter matching problem for the TUM Garching Campus?

3. How to design and implement a platform for daily ride-sharing at TUM Garching Campus?



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Methods: State-of-the-art Literature Review

- Five stages of ride-sharing[4] starting in US:
  1. World War II car-sharing (or carpooling) clubs[5]
  2. Responses to the 1970s energy crises driven by High-Occupancy-Vehicle lanes[6,7]
  3. Ride-sharing schemes organized by cities and municipalities[8]
  4. Reliable ride-sharing systems having prearrange and static rides[10]
  5. Technology-enabled ride-matching: GPS, mobile computing, platform technology[11]

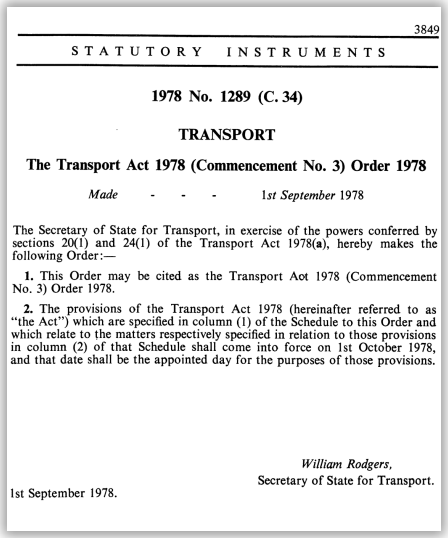
Poster in the US during WWII to promote Carpooling[3]

[3] www.upload.wikimedia.org
[4] *Ridesharing in North America: Past, Present, and Future,* Nelson D. Chan 2012
[5] *Columbia Law Review*, 1942
[6] *Regional structural elements in Northwest Germany,* JC Pratsch 1979
[7] *Casual carpooling-enhanced,* KL Kelly 2007
[8] *Impacts of Employer-Based Trip Reduction Programs and Vanpools on Passenger Vehicle Use and Greenhouse Gas Emissions*, Marlon G. Boarnet 2014
[10] *Ridematching online: an evolution in service delivery,* D Bower 2004
[11] *Seattle smart traveler: dynamic ridematching on the World Wide Web,* D.J.Dailey D.Loseff D.Meyers 1999

Methods: State-of-the-art Literature Review

- The 1978 Transport Act changed legal situation in UK[15,16]
  - Increased number of allowed fare-paying passengers from 4 to 7
  - Allowed official advertisement to promote private ride-sharing

- Major considerations for solutions to reach "critical mass" [4]:
  - Regional and large employer partnerships[12]
  - Financial incentives[13,14]
  - Social networking with younger populations
  - Real-time mobile services with automated ride-matching software[7]



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STATUTORY INSTRUMENTS

1978 No. 1289 (C. 34)

TRANSPORT

The Transport Act 1978 (Commencement No. 3) Order 1978

Made - - - 1st September 1978

The Secretary of State for Transport, in exercise of the powers conferred by sections 20(1) and 24(1) of the Transport Act 1978(a), hereby makes the following Order:—

1. This Order may be cited as the Transport Act 1978 (Commencement No. 3) Order 1978.

2. The provisions of the Transport Act 1978 (hereinafter referred to as "the Act") which are specified in column (1) of the Schedule to this Order and which relate to the matters respectively specified in relation to those provisions in column (2) of that Schedule shall come into force on 1st October 1978, and that date shall be the appointed day for the purposes of those provisions.

William Rodgers,
Secretary of State for Transport.

1st September 1978.

1978 Act of Transportaion[15]

[4] *Ridesharing in North America: Past, Present, and Future,* Nelson D. Chan 2012
[7] *Casual carpooling-enhanced,* KL Kelly 2007
[12] *Innovative public-private partnership models for road pricing/BRT initiatives,* P DeCorla-Souza, WG Barker 2005
[13] *Ridesharing on timetabled transport services: A multiagent planning approach*, J Hrnčíř 2015
[14] *Proposed Methodology for Estimating Rideshare Viability Within an Organization: Application to the MIT Community,* A Amey 2015
[15] *1978 Transport Act,* House of Commons 1978
[16] *Pooling for the journey to work: The outlook in Great Britain*, PAK Greening 1984

Methods: State-of-the-art Analysis of Existing Approaches

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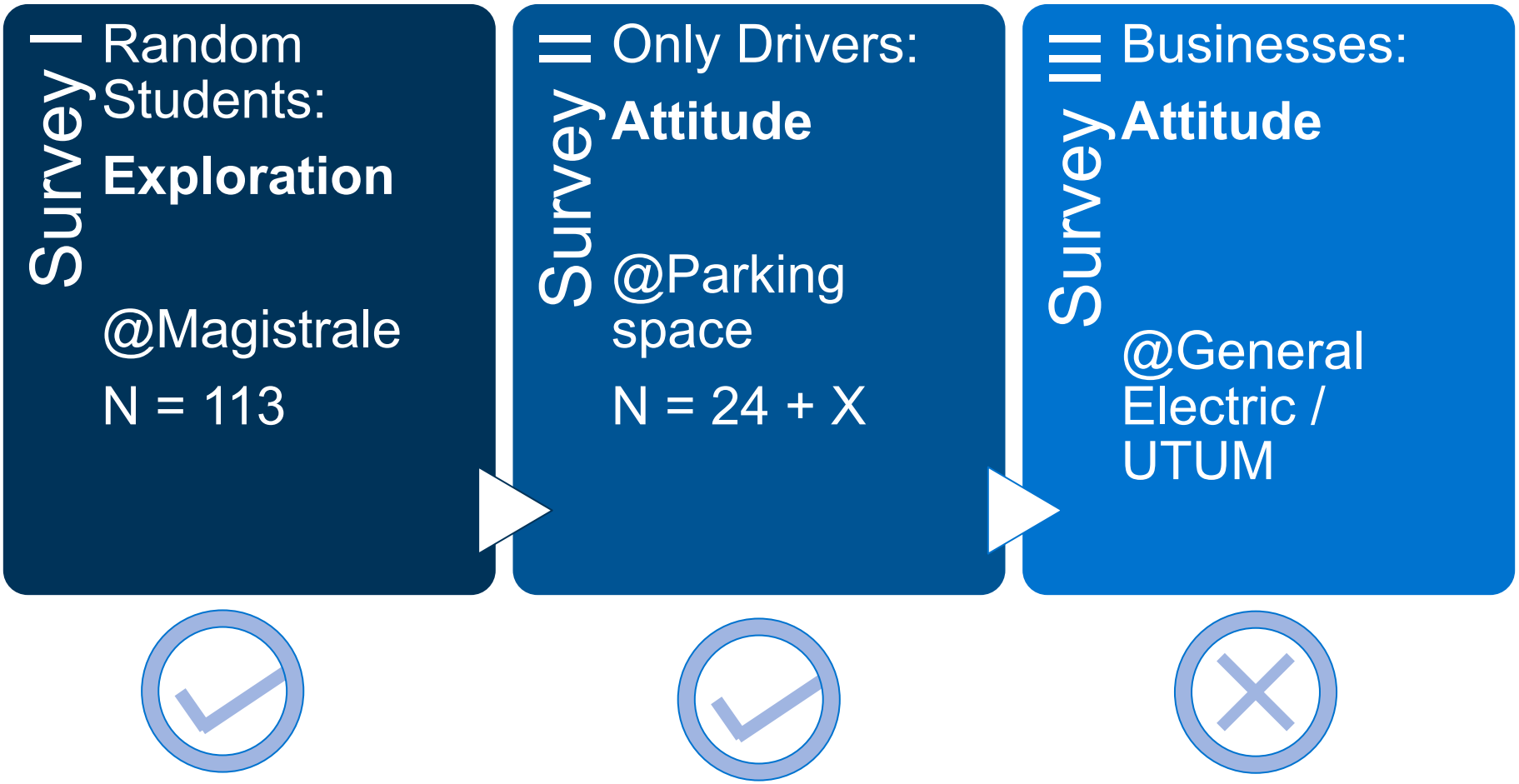
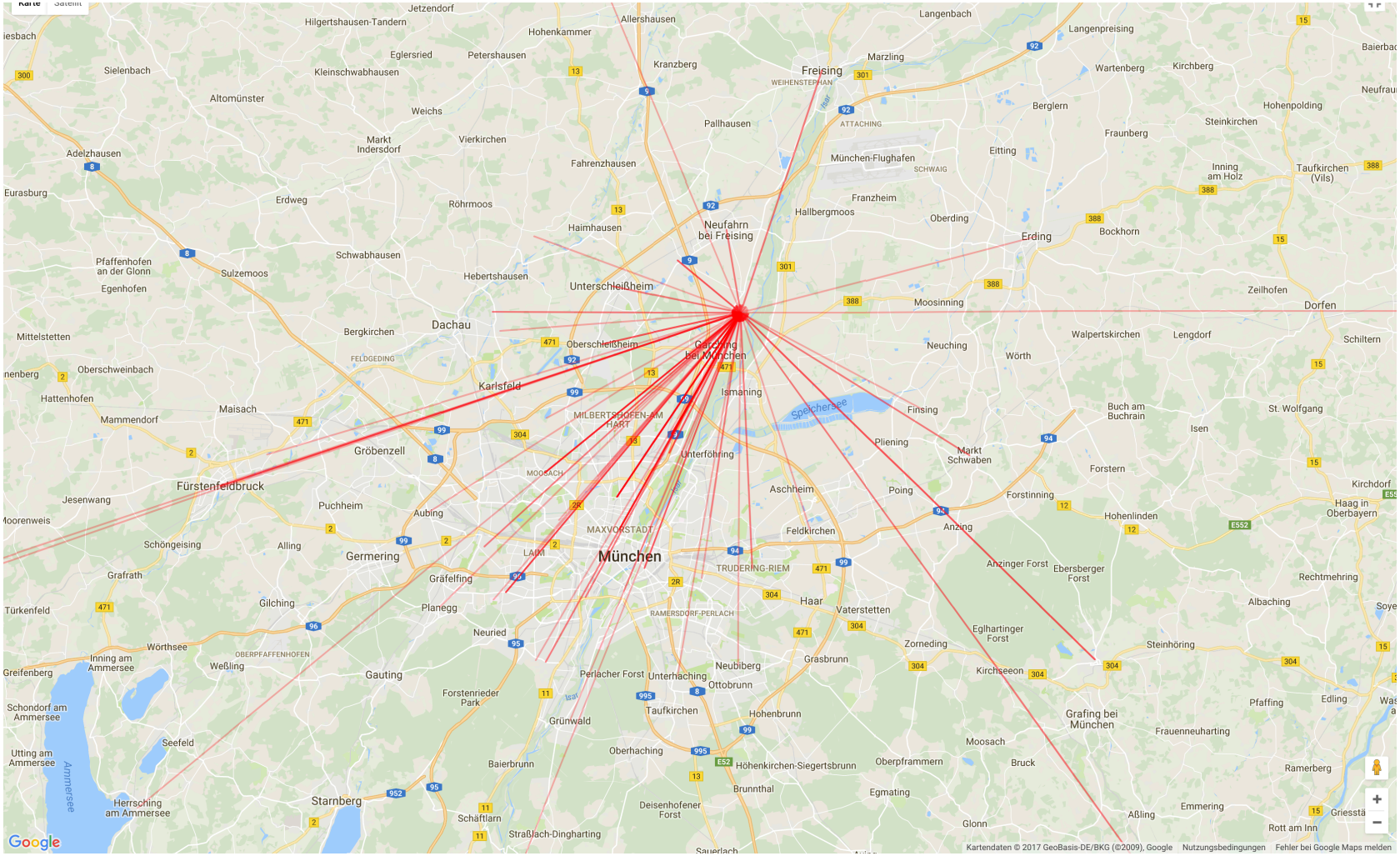
Methods: Empirical Research

- Survey Designs



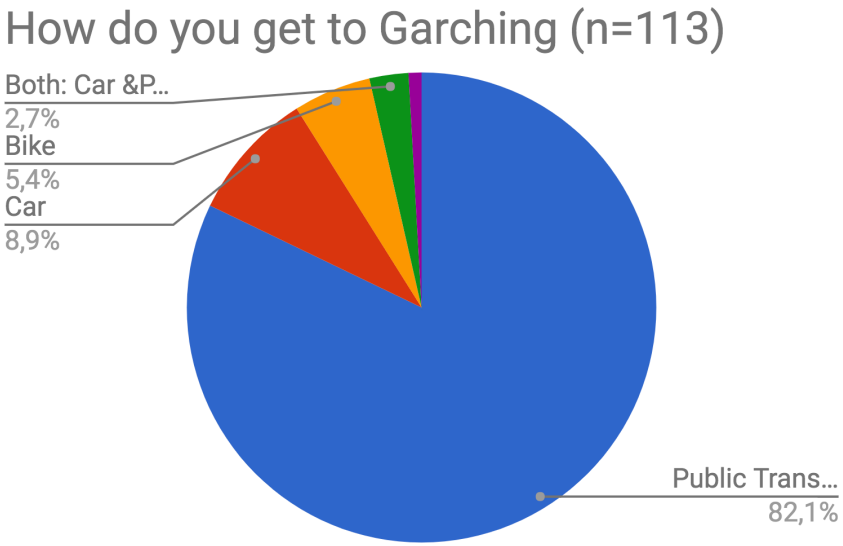
Methods: Empirical Research

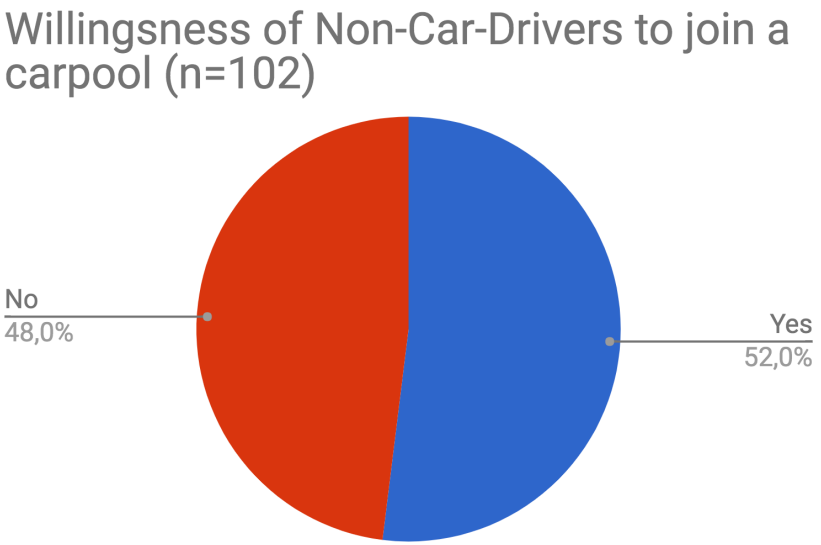
- Survey I Findings (n=113): Commuting Directions



Methods: Empirical Research

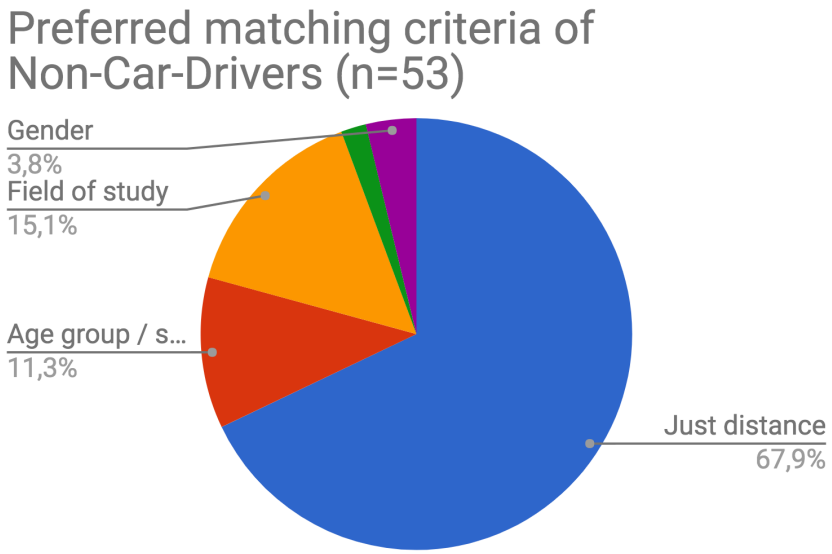
- Survey I Findings (n=113): Overall Attitude

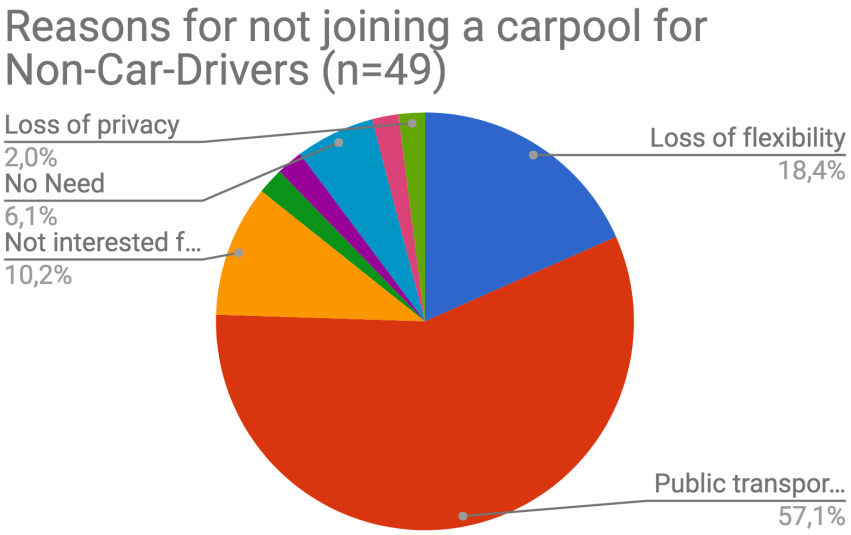




Methods: Empirical Research

- Survey I Findings (n=113): Overall Attitude





Methods: Empirical Research

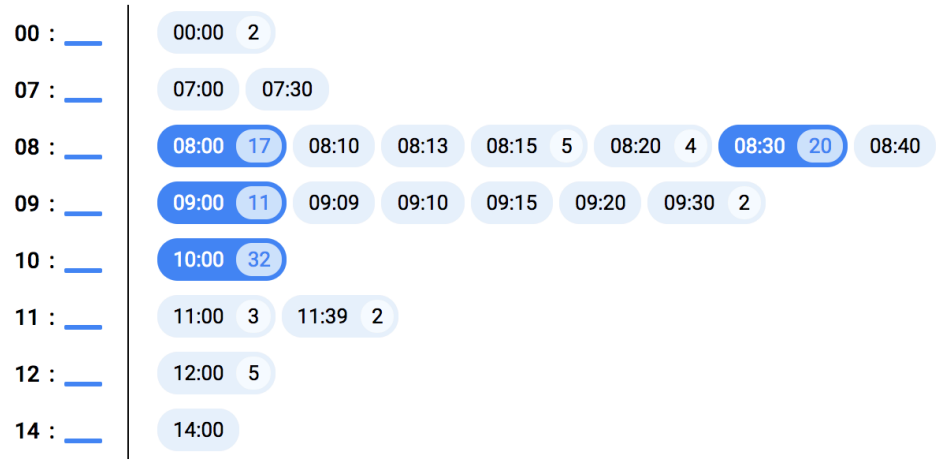
- Survey I Findings (n=113 + 24): Price Elasticity

Methods: Empirical Research

- Survey I Findings (n=113): Arrival and Departure Time

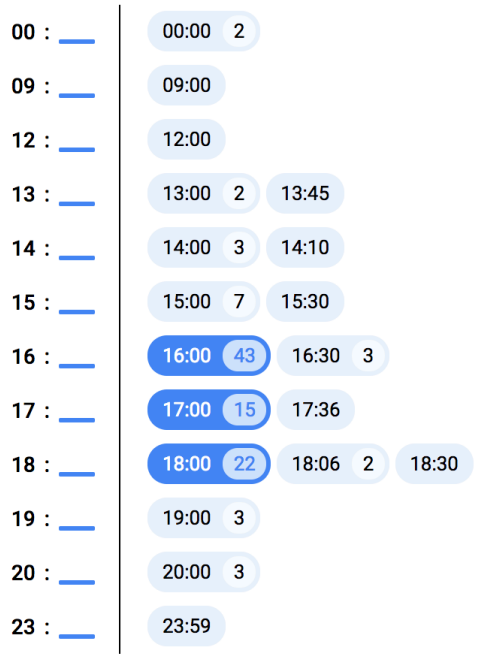
At what time do you usually arrive in Garching on weekdays?

113 responses



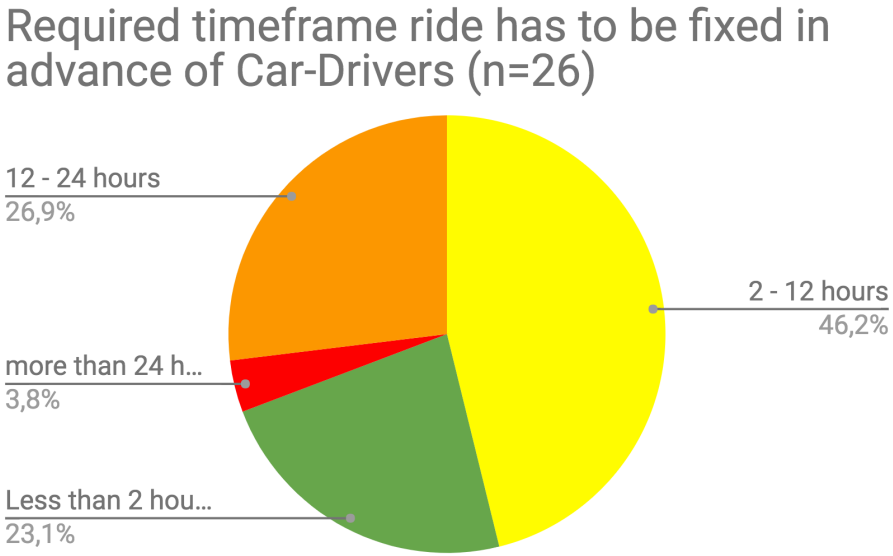
At what time do you usually leave Garching on weekdays?

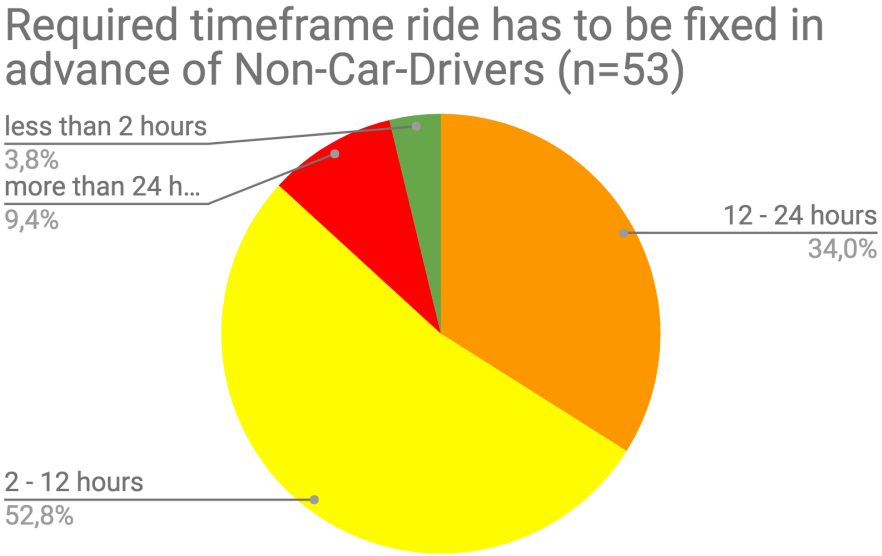
113 responses



Methods: Empirical Research

- Survey I + II Findings (n=113 + 24): Time Flexibility





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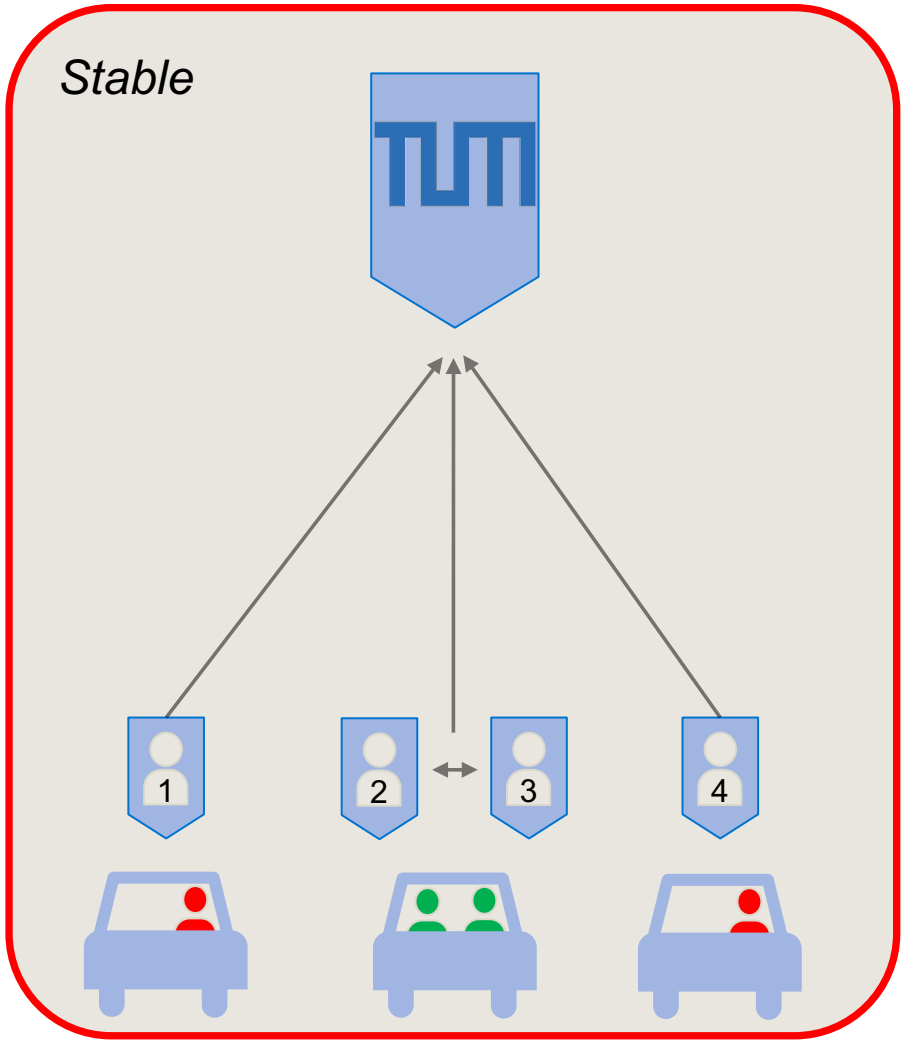
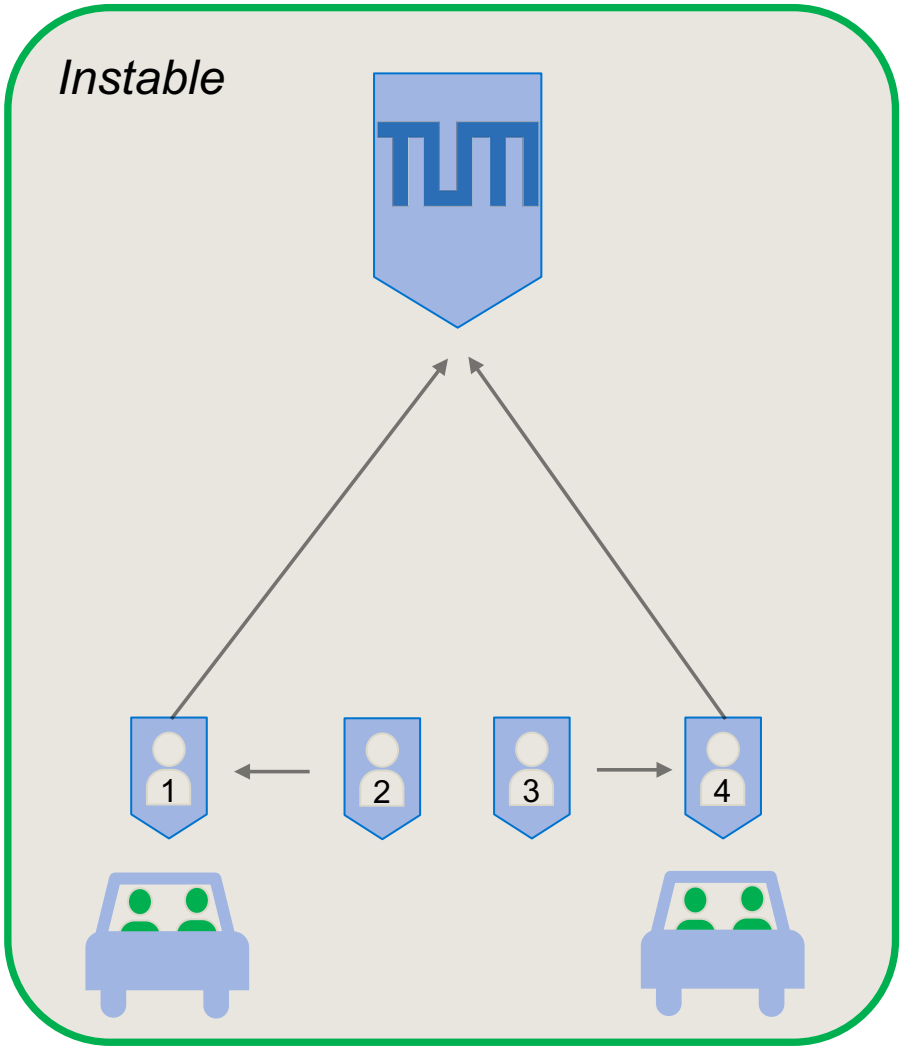
Methods: Modeling as an Optimization Problem

- Basic Differentiation: Agent-based vs. Central-Assignment (capacity = 2)





Methods: Modeling as an Optimization Problem

- Formalizing the ride-matching problem as a combinatorial optimization problem
- Find the best matching solution out of the set of all feasible solutions
  - optimizing the Target function:

$$Minimize\left(\sum number\ of\ cars\ used + traveled\ distance + waiting\ time + \cdots\right)$$

  - Maintaining the Constraints:

$$\sum_{p \in Passangers} travels\ with_{p,c} \leq capacity_c \qquad \forall c \in Cars$$

…

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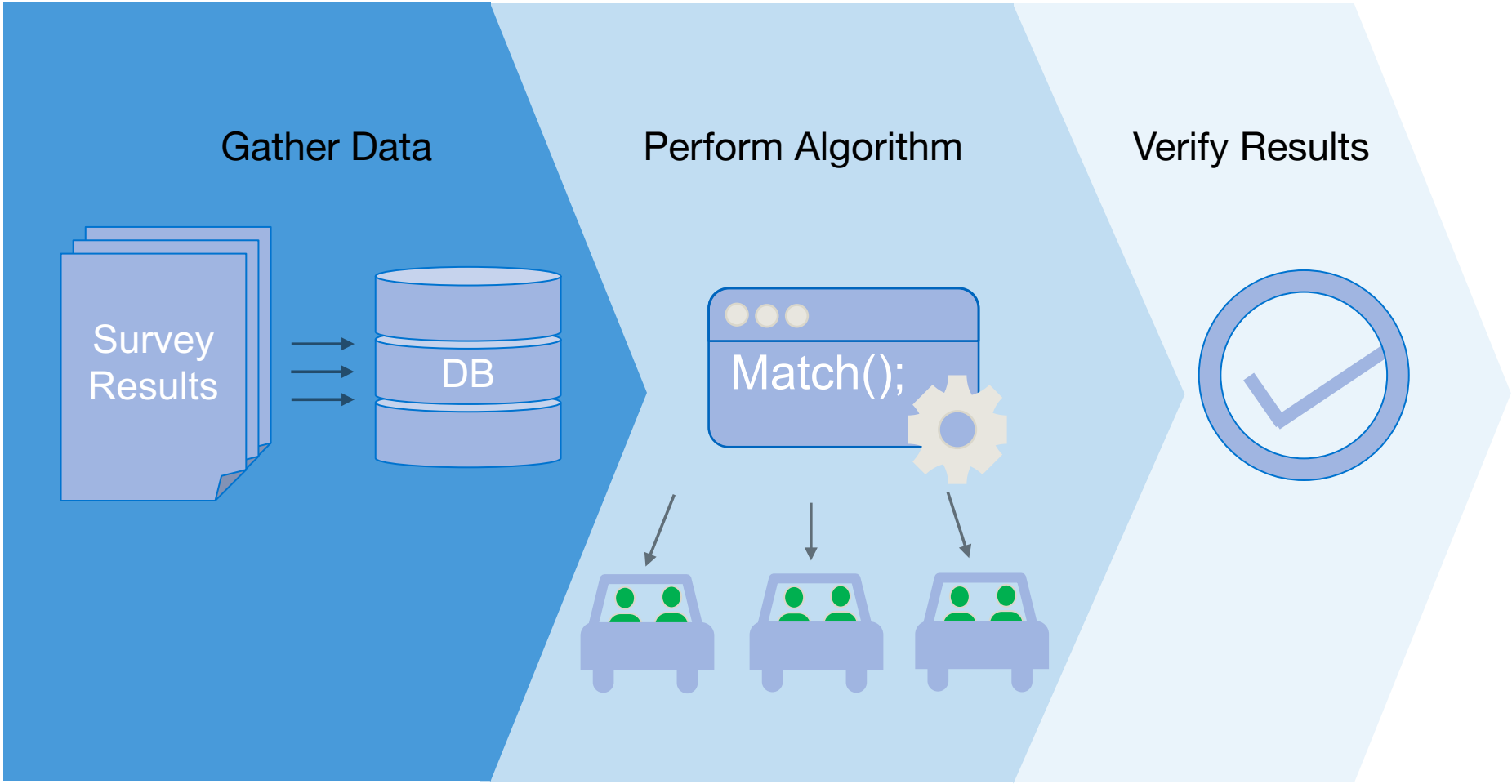
Methods: Software Implementation and Evaluation

- Technology Stack

Methods: Software Implementation and Evaluation

- Simulate simultaneous platform users to evaluate the matching algorithm



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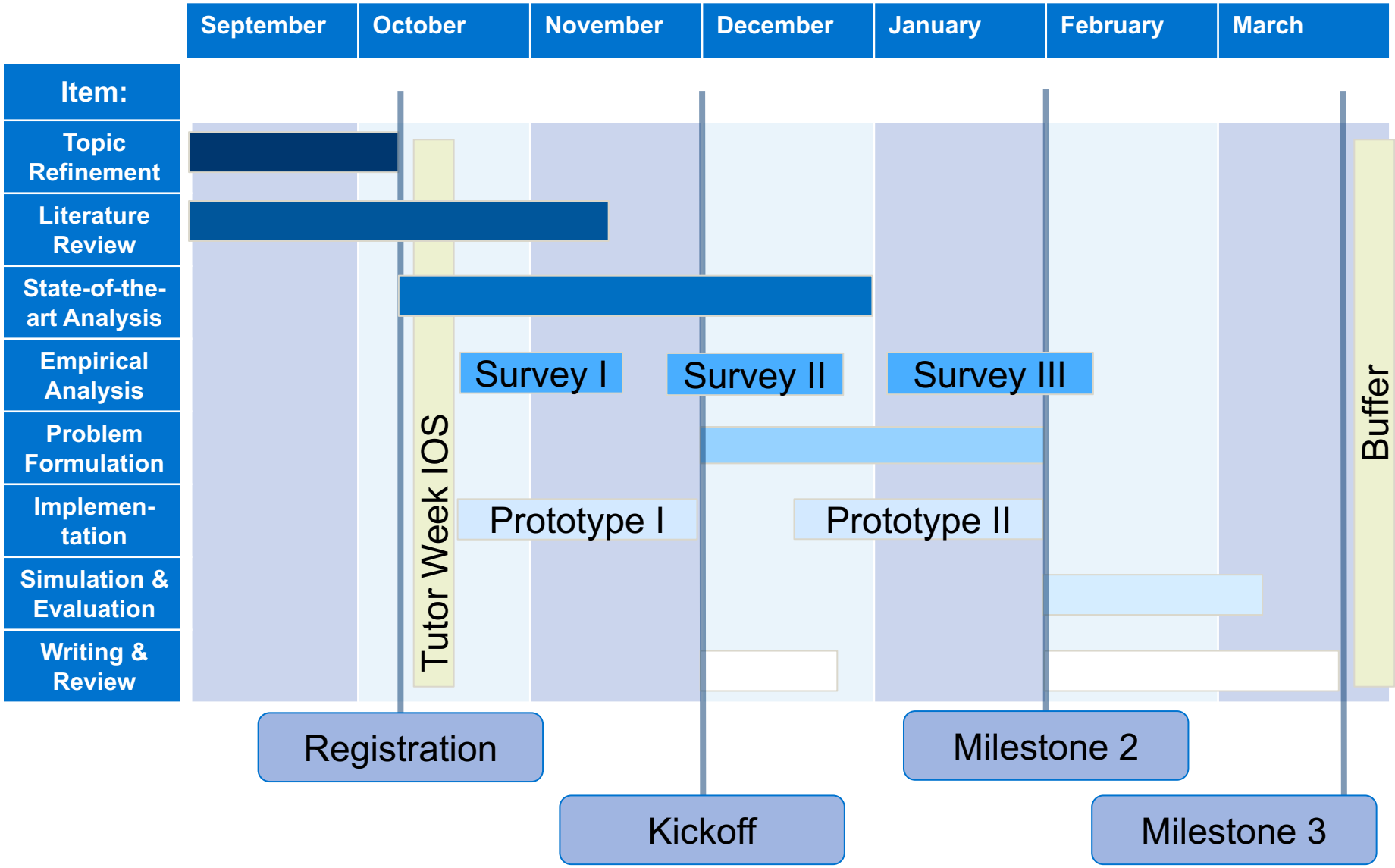
Rough Planned Schedule



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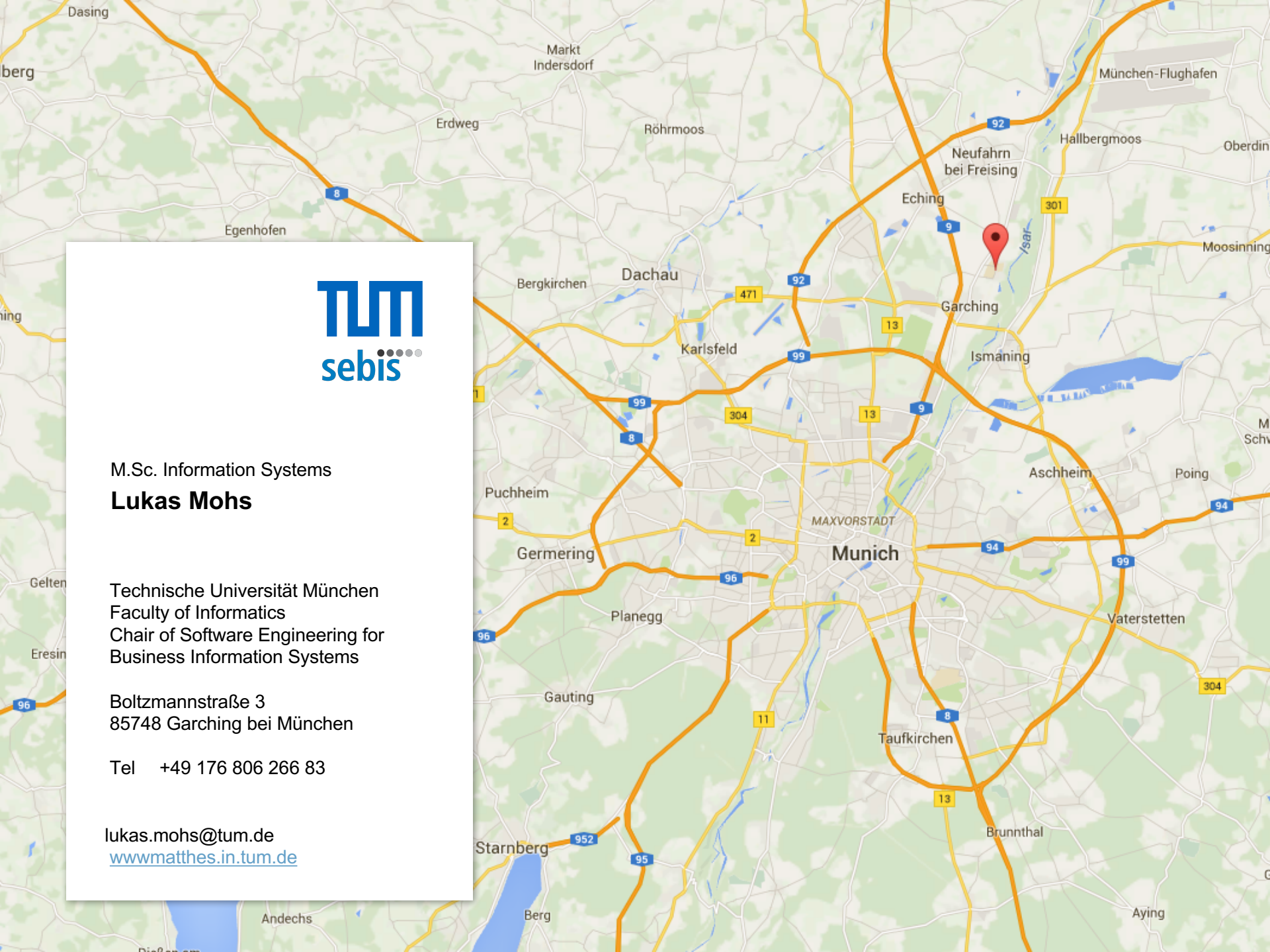
Thank you for your attention!

- Questions?
- Suggestions?

- If you want to follow the current Prototype:

http://my.fastpool.eu/



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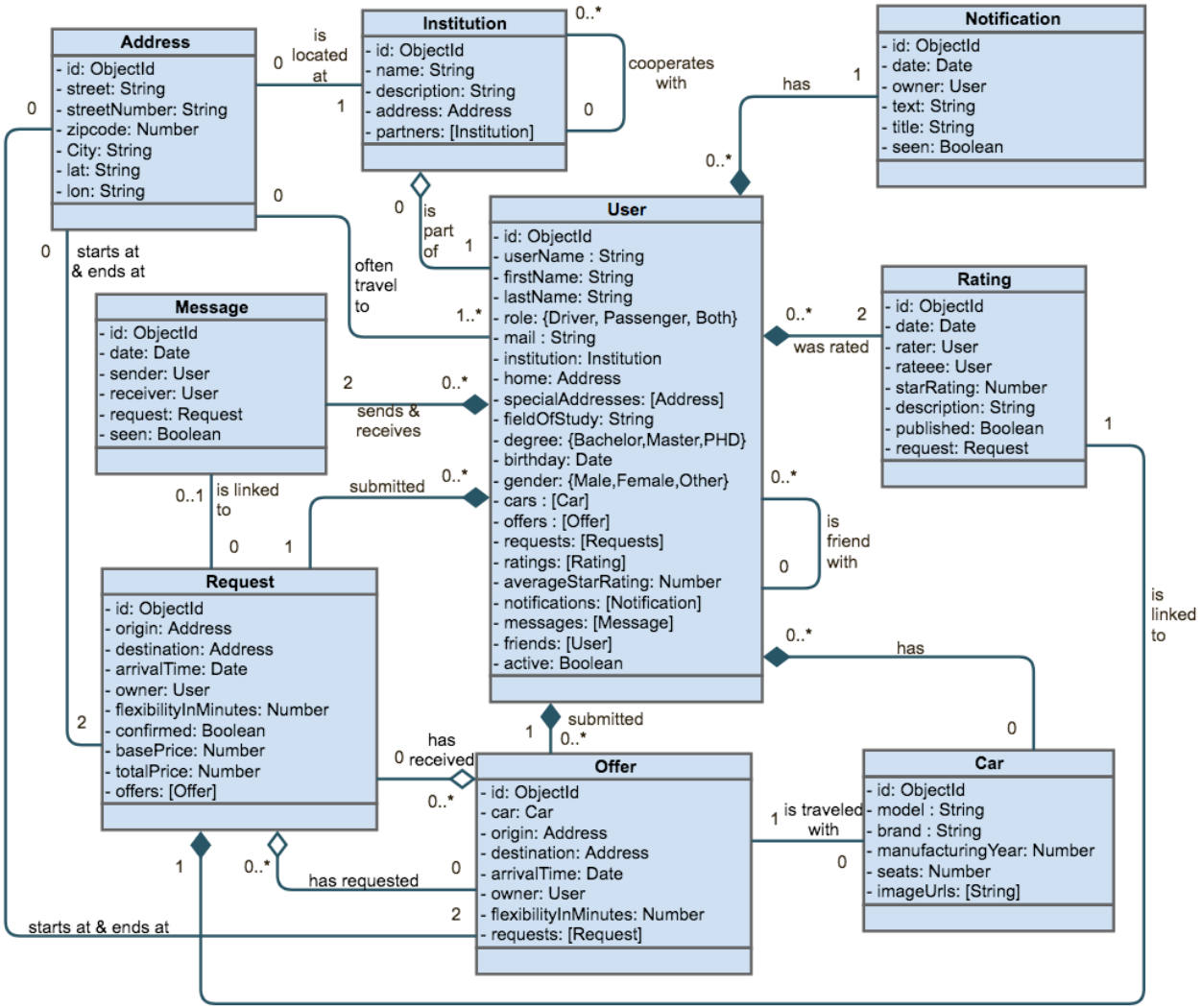
Backup: Software Implementation and Evaluation

- Entity Architecture



User central entity

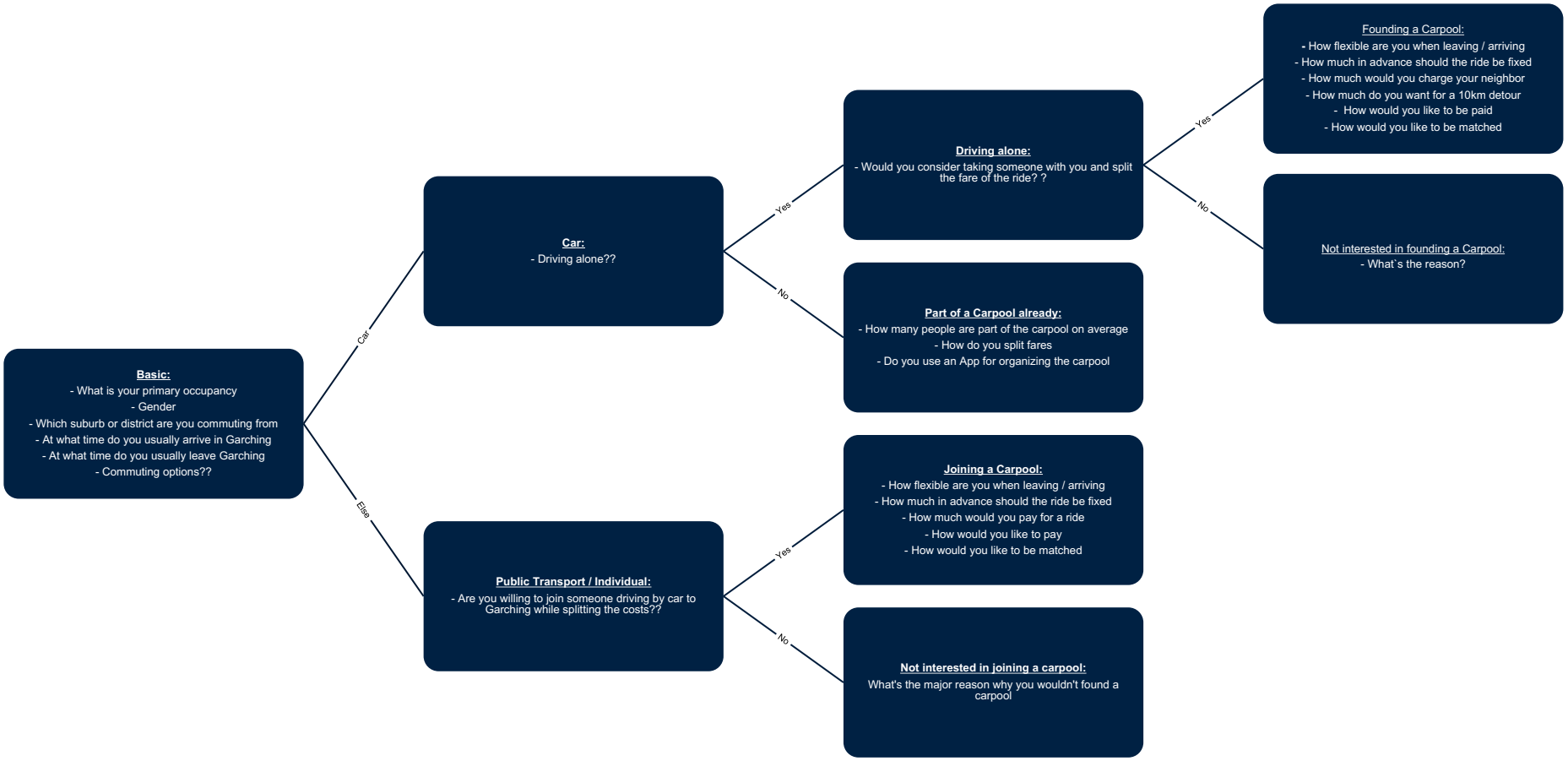
- Associated with institution

Loosely coupled Request and Offer entity

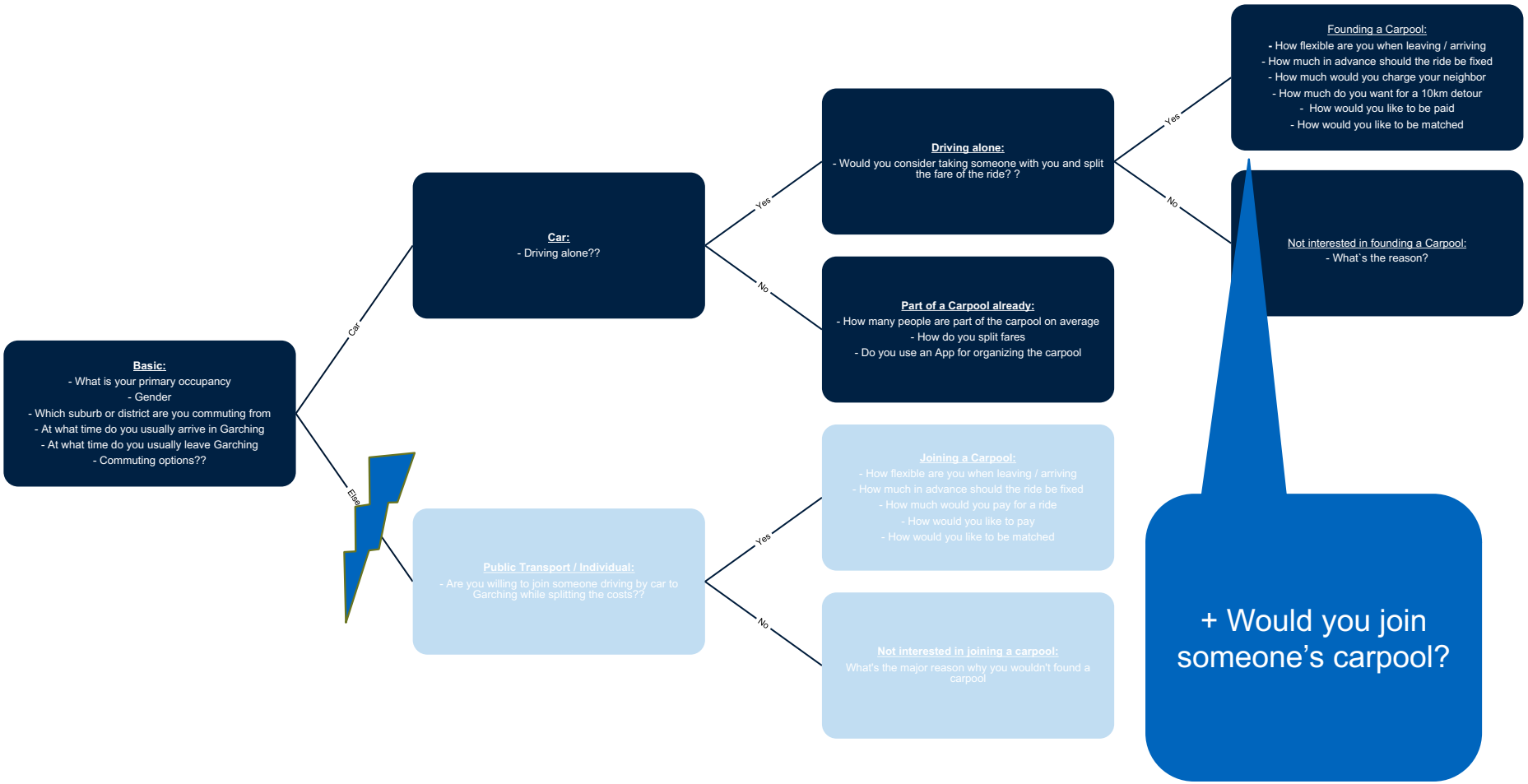
- Enable central / asynchronous matching
- Notification informs about new matches

Message and Rating realize platform confidence

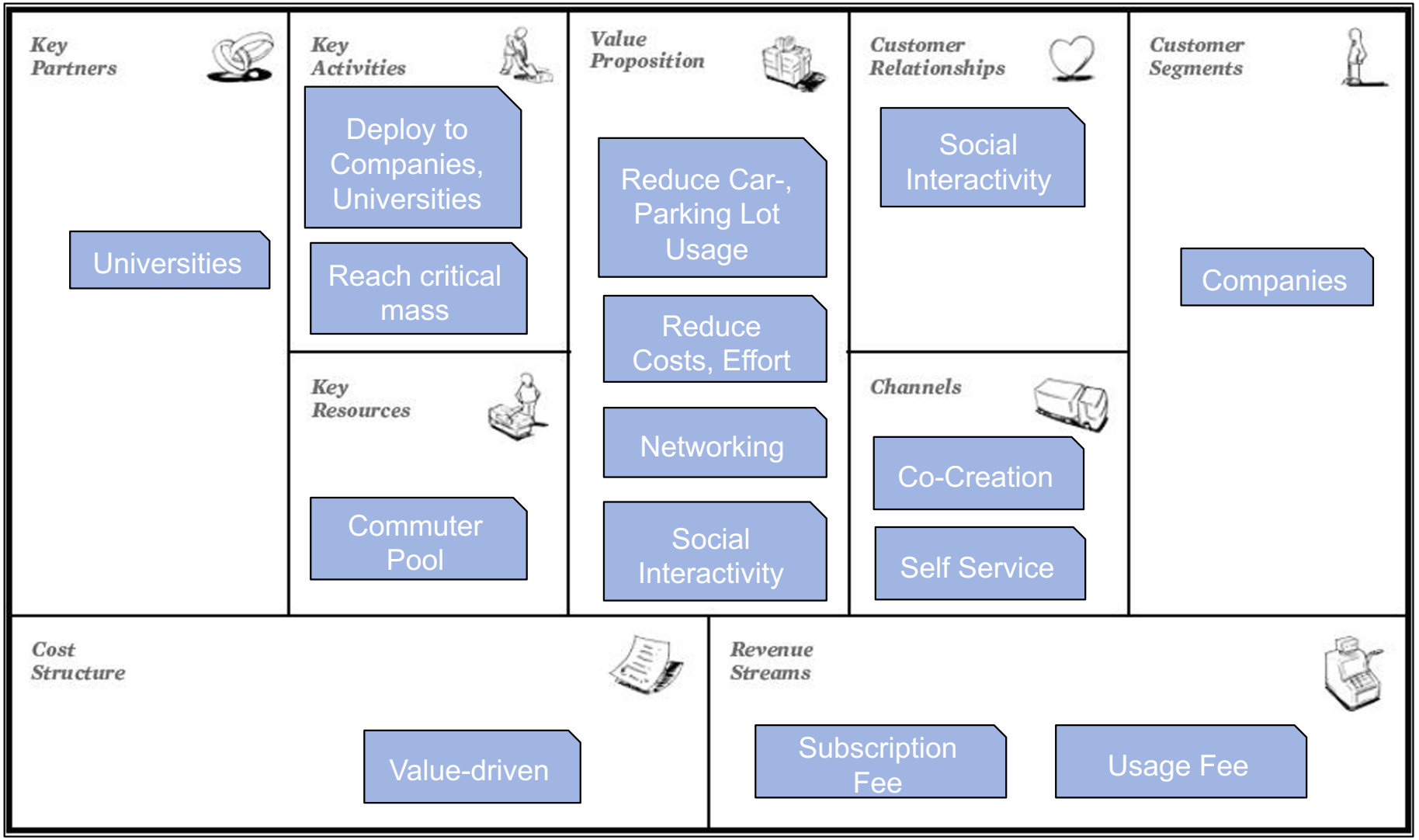
Backup: Survey I Design



Backup: Survey II Design



Backup: Business Model Canvas



http://wordpress-innovately.rhcloud.com/wp-content/uploads/2015/04/business-model-canvas.jpg

Backup: Further References (I)

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 de Technologie de Troyes, 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

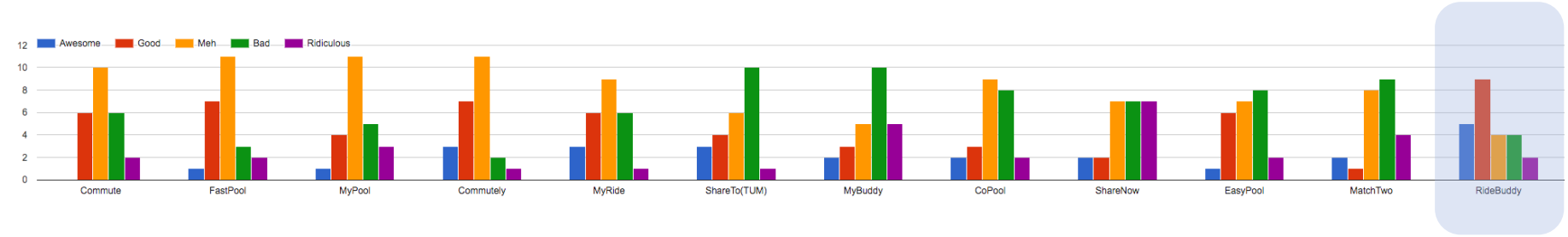
Backup: Further References (II)

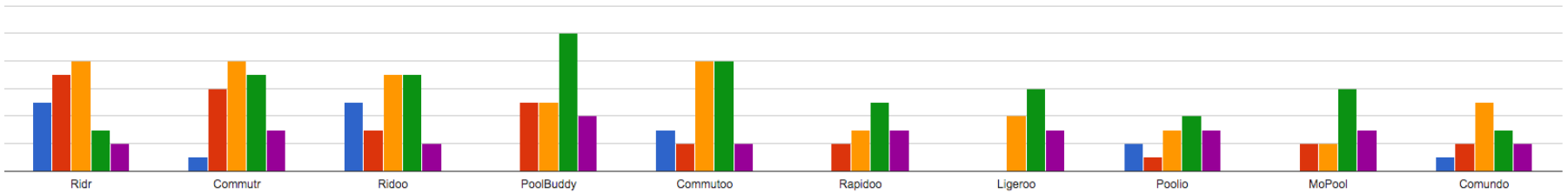
21	Los Angeles Smart Traveler Field Operational Test Evaluation	Report	1995	University of Southern California, Berkeley
22	The Determinants of Ridesharing: A Literature Review.	Working Paper	1990	University of California Transportation Center
23	Casual Carpooling—Enhanced	Article	2007	Association for 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
35	Mobilität in Deutschland 2008	Report	2008	Bundesministerium für Verkehr, Bau und Stadtentwicklung

Icons (flaticon.com)

- Tomas Knop
- Zlatko Najdenovski
- Freepik

Backup: Name Survey





Backup: Background - 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.

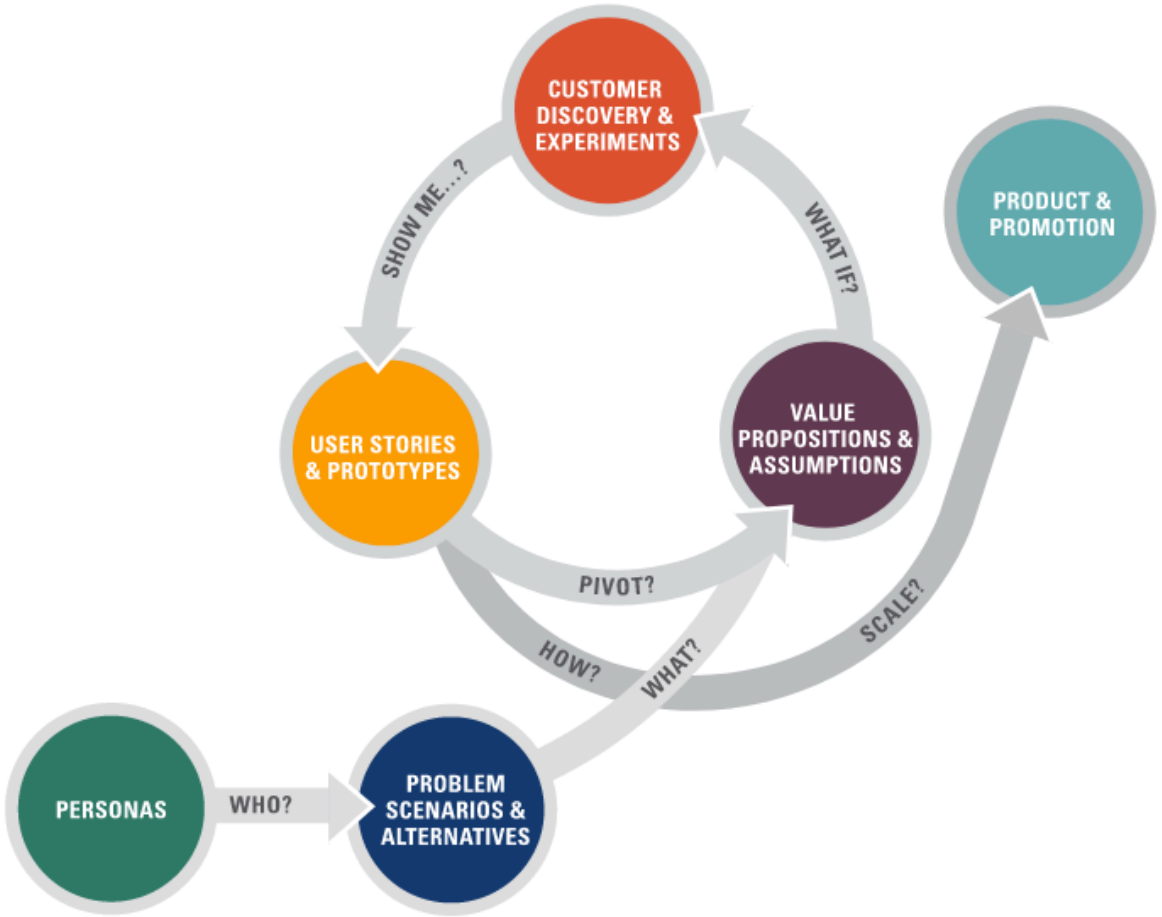
Backup: Literature Review (I)

- 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 [2,4,5,6,7,8,10,11,12,13,14,15,18,19,20,21,22,23,25,26 ,28,29,30,32].
- Further studies discussed the potential for ridesharing for single universities or companies [9,24,27,31].

Backup: Literature Review (II)

- 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].

Backup: Venture Design



https://www.alexandercowan.com/venture-design