A framework for a vehicle sharing system

Selin Ataç, Nikola Obrenović, Michel Bierlaire

Transport and Mobility Laboratory School of Architecture, Civil and Environmental Engineering École Polytechnique Fédérale de Lausanne

June 26, 2019



Outline









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What is a Vehicle Sharing System (VSS)?

A VSS enables users to use the available vehicles generally for short period of time by an RFID card or smart phone application identification.

• Various system configurations

- One-way or return trip
- Station-based or free-floating
- Rebalancing with operators or trucks
- Dynamic or fixed pricing
- ...

Car-sharing companies



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Bike-sharing companies



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Imbalance in the network

- Bicycle-sharing systems (BSSs)
 - Vehicle routing problem (VRP) (Ghosh et al., 2016 & Liu et al., 2016)
 - Capacitated traveling salesman problem (TSP) (*Pal and Zhang et al., 2017*)
- Car-sharing systems (CSSs)
 - Multi-TSP (Nourinejad et al., 2015)
 - Mixed Integer Linear Programming (MILP) models (*Boyaci et al., 2017*)
 - Importance of the relation between demand forecasting and rebalancing (*Jorge and Correia, 2013*)
 - Denial of the requests in the case of high demand (Boyaci et al., 2017)

Demand estimation

BSSs

- Machine learning algorithms (Liu et al., 2016)
- Simulating the demand with a Poisson process (Ghosh et al., 2016)
- Worst-case demand (Ghosh et al., 2016)
- CSSs
 - AutoRegressive Integrated Moving Average (ARIMA) (*Müller and Bogenberger, 2015*)
 - Holt-Winter's method (Müller and Bogenberger, 2015)

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Pricing

BSSs

- Prices are assigned dynamically independently of their origin or depending on the itinerary of the customer. (*Chemla et al., 2013, Waserhole, 2013*)
- Dynamic pricing improved the level of service for the weekends. (*Pfrommer et al., 2014*)
- CSSs
 - Incentives on pricing which encourages users to do trips which reduces the imbalance of the network. (*Jorge and Correia, 2013*)
 - Balance of the system is improved, but less demand is served. (*Jorge and Correia, 2013*)

Big picture

• Shared mobility systems: an updated survey by Laporte et al., (2018)

- Two dimensional classification
 - Type of the problem
 - Decision level
- Lack of research in some specific areas
 - Pricing incentives and routing problems at strategic level
 - Locating stations in tactical and operational levels
- This work aims to provide a holistic solution approach for the VSSs.
 - From decision maker point of view
 - Three dimensional classification
 - Supply and Demand
 - Data, Models, and Actions
 - Decision levels: Strategic, Tactical, and Operational
 - Relations between the components

A decision level

• A first look to the general framework



Figure: General framework - the first look

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Strategic level

- Corresponds to long-term decisions
 - What kind of system are we dealing with?
 - How is the scope defined?
- Planning horizon
 - More than a year



Figure: General framework - strategic level

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Tactical level

- Corresponds to mid-term decisions
 - How do we utilize the strategic level decisions?
 - Which decisions should we pass to the operational level?
- Planning horizon
 - 4-6 months



Figure: General framework -- tactical level

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Operational level

- Corresponds to short-term decisions
 - What is the current situation of the system?
 - What do we do next time step?
- Planning horizon
 - Daily/hourly



Figure: General framework - operational level

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Big picture - revisited



Figure: General framework and inter-relations

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Big picture - revisited

- The literature consists works on BSSs and CSSs.
- New types of vehicles are being introduced in VSSs.
- However, some of the approaches become inapplicable for the new types of vehicles.

An example - Light Electric Vehicles (LEVs)

• A new type of Light Electric Vehicles (LEVs)



- You don't need a car driving license
- You can ride on bicycle lane
- You are protected from bad weather

Image: A matrix and a matrix

- There's a room for luggage
- Free-floating parking

- The system is available to a higher portion of the population.
- Conventional rebalancing ideas should be adapted.
- Free-floating structure is not widely studied.

Conclusion and future work

- A general framework for VSSs is presented.
- Inter- and intra-relations between framework components are discussed.

- An application will be done on newly introduced LEVs.
- We will focus on a specific component of the framework.
- Demand forecasting component is quite promising. We will first analyze the added value of constructing a disaggregate demand model.
 - Simulating the system
 - Comparison between perfect information and no information on demand



selin.atac@epfl.ch



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