A general management framework for vehicle sharing systems

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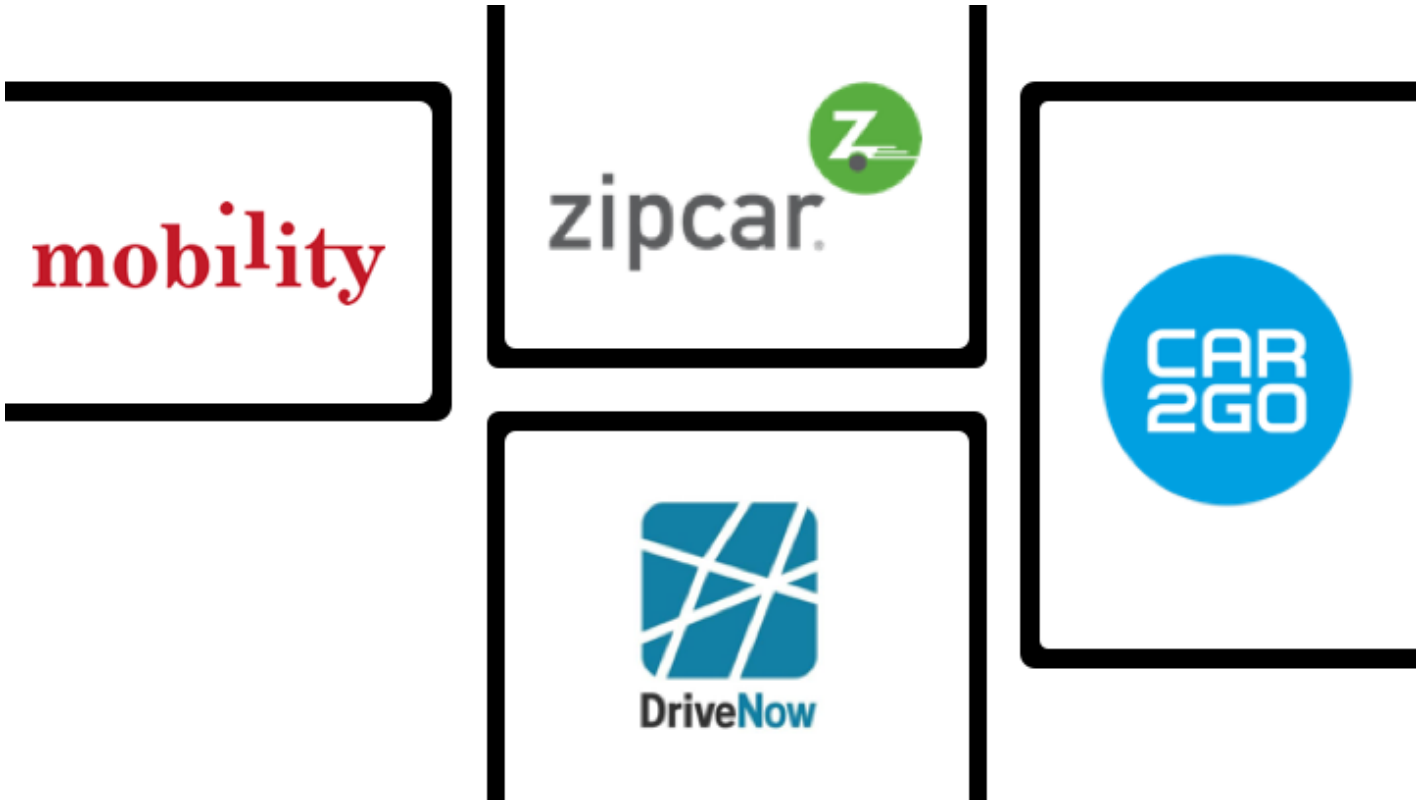
Outline

What is a Vehicle Sharing System (VSS)?

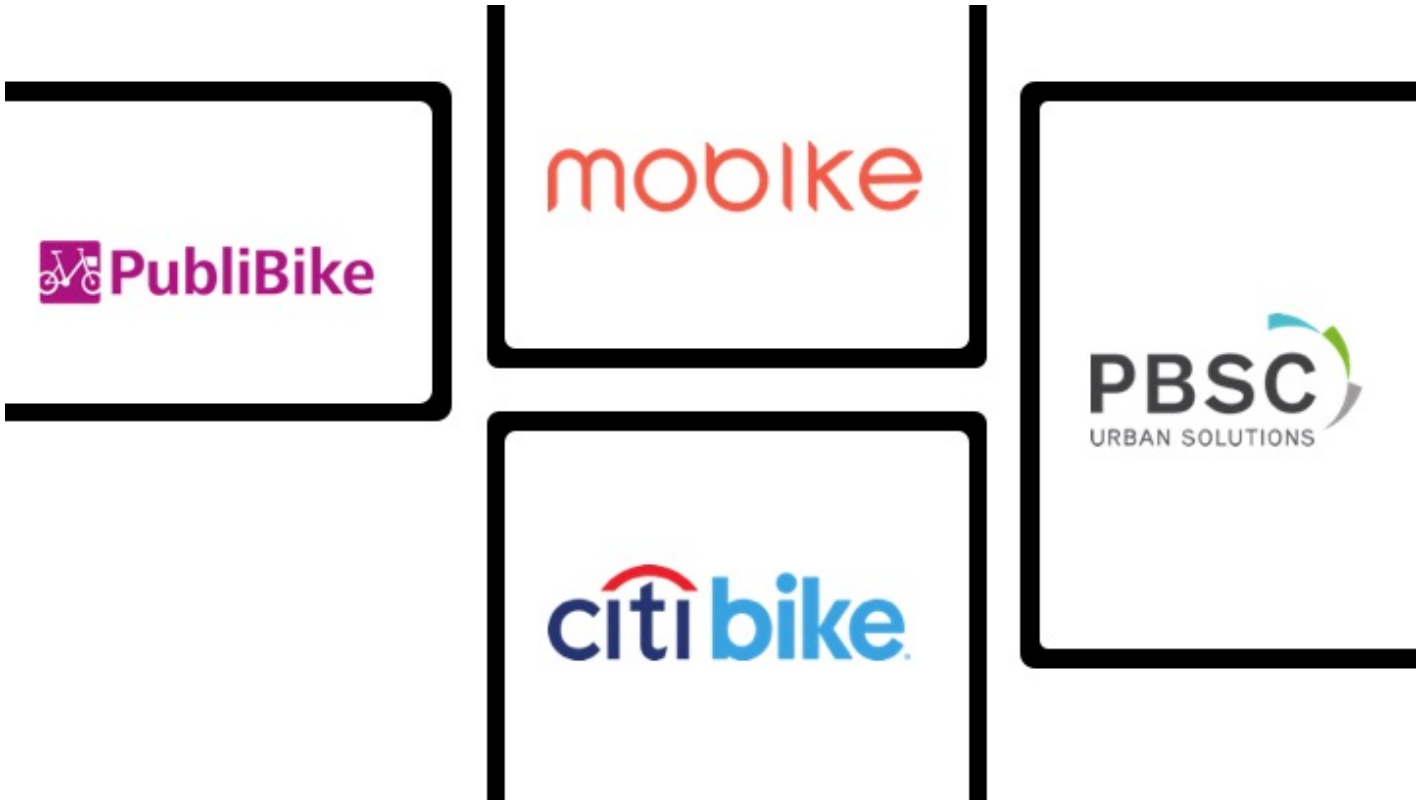
A VSS enables users to use the available vehicles generally for short period of time by an RFID card or smart phone application identification.

- How are they operated?
  - One-way or return trip
  - Station-based or free-floating
  - Rebalancing with operators or trucks
  - Dynamic or fixed pricing
  - ...

Car-sharing companies



Bike-sharing companies



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*)

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

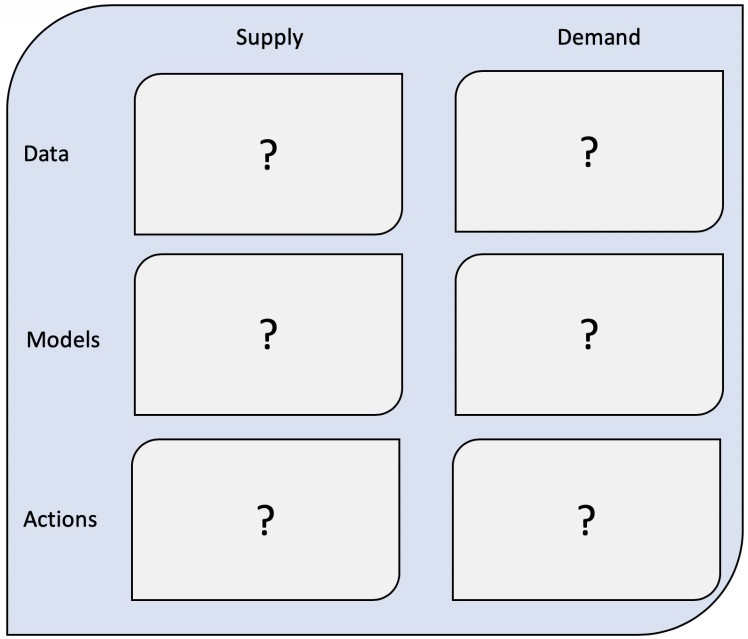


Figure: General framework - the first look

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

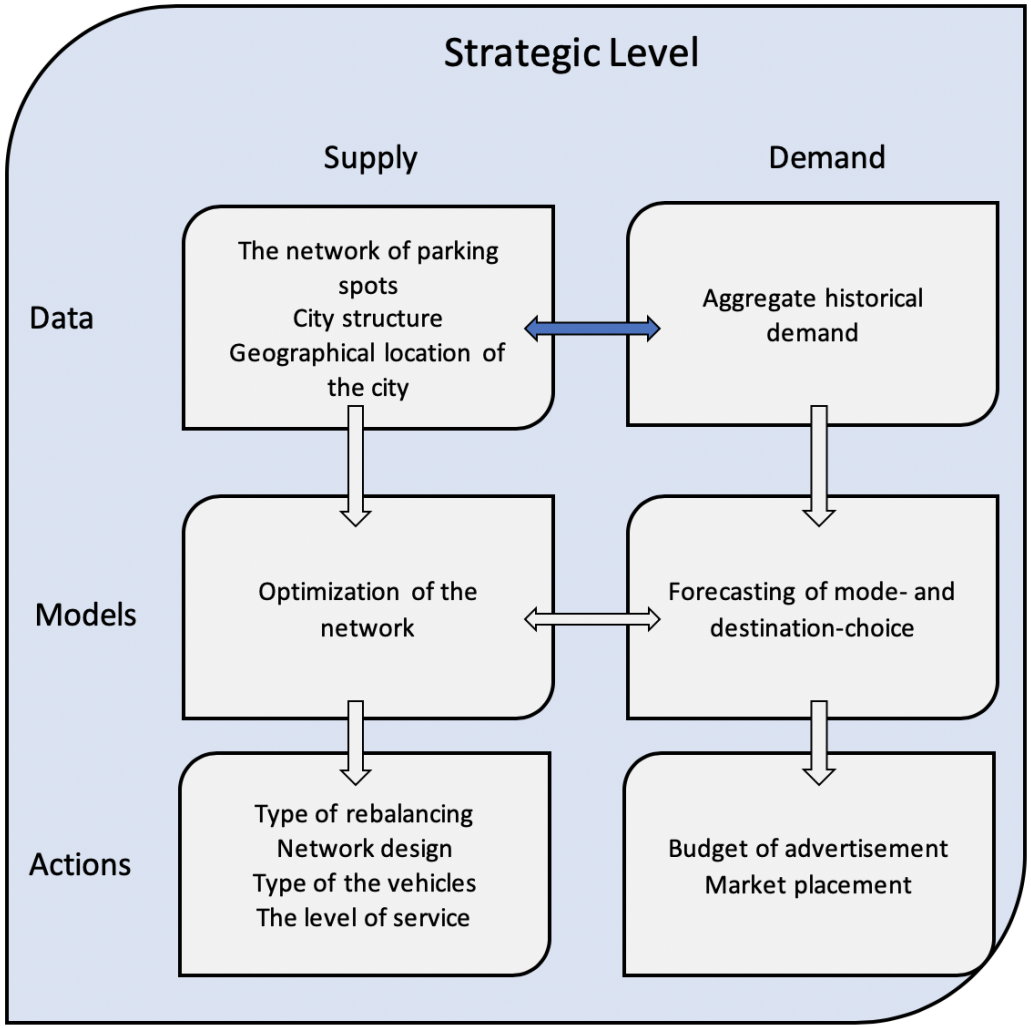


Figure: General framework - strategic level

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

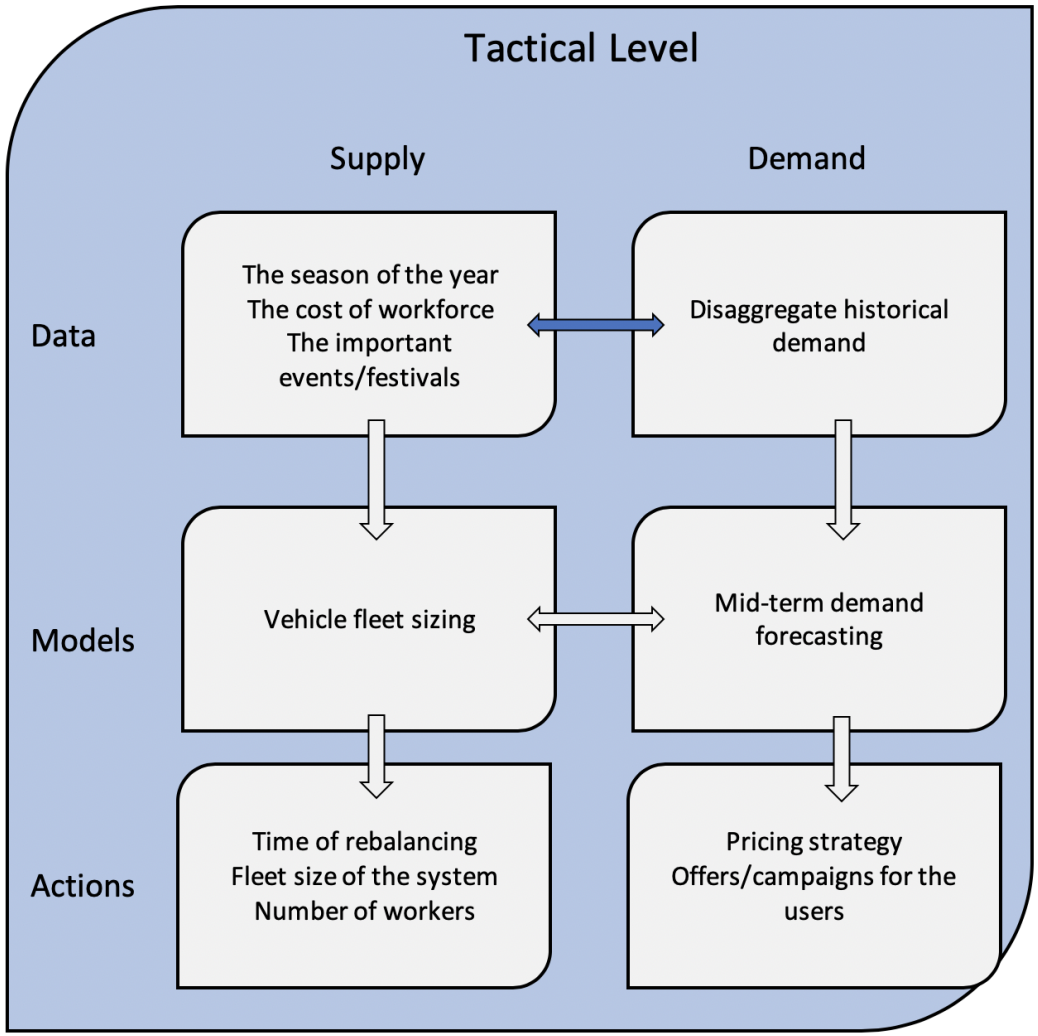


Figure: General framework -tactical level

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

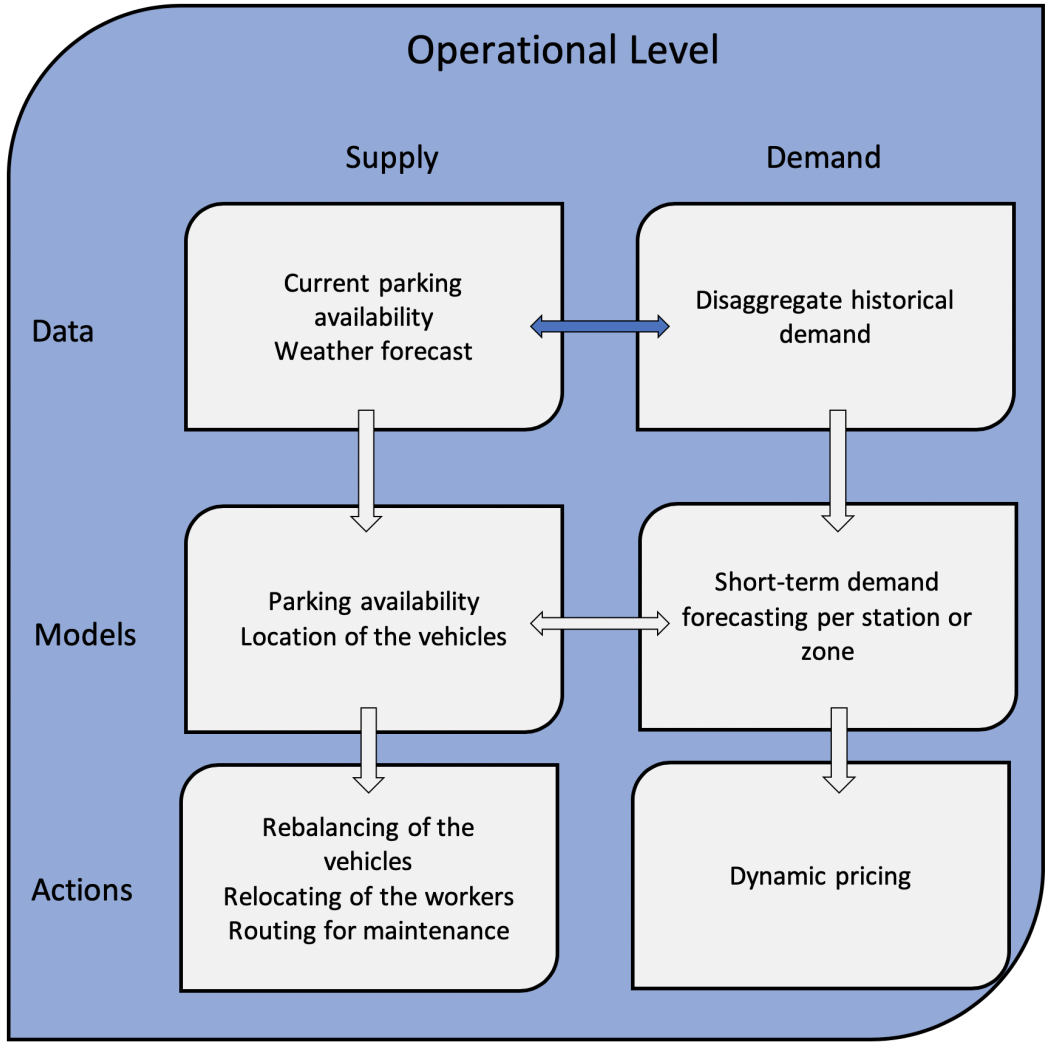


Figure: General framework - operational level

Big picture - revisited

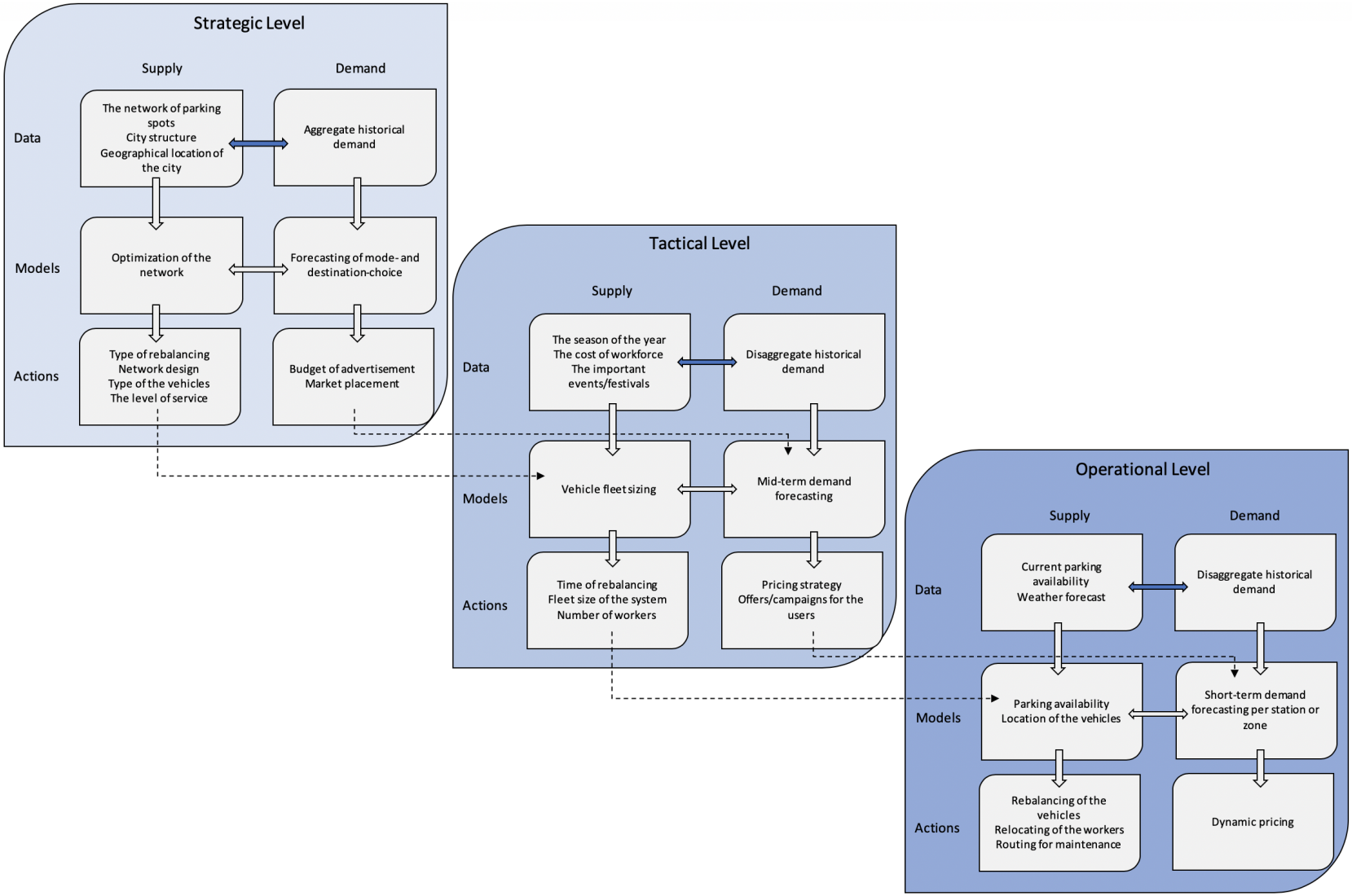


Figure: General framework and inter-relations

An application - Light Electric Vehicles (LEVs)

- 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
- 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.

- We will apply the framework 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.

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