Robust Facility Location Under Uncertainty in Customer Behavior

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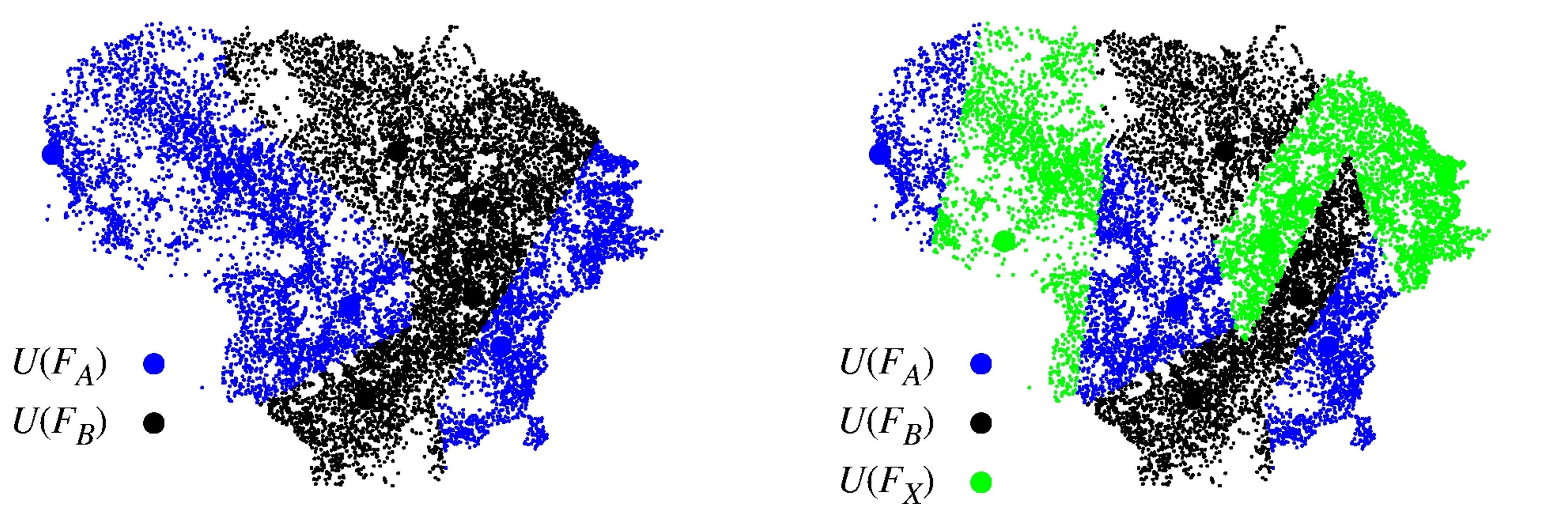
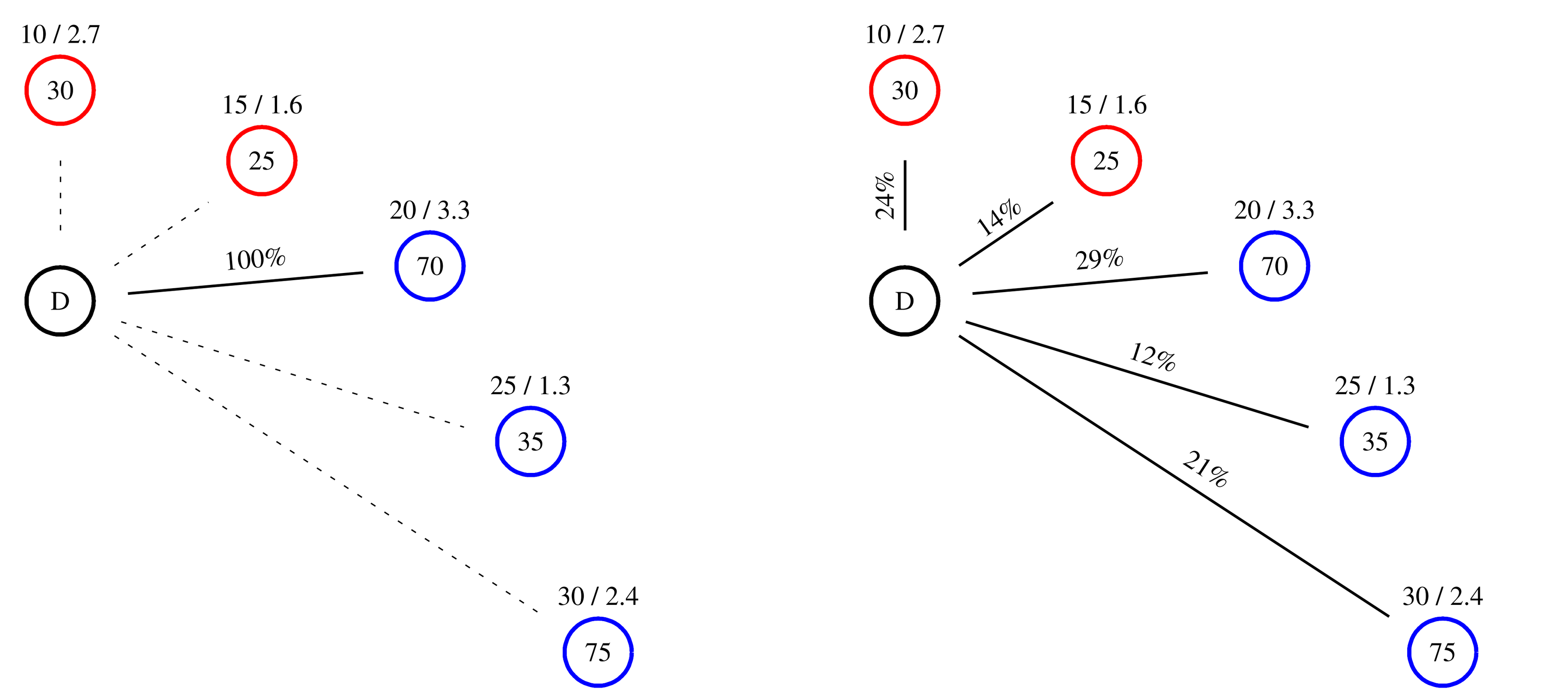
Facility Location

Facility location problems focus on determining optimal locations for facilities such as stores, warehouses or factories to efficiently satisfy customer demand in a certain geographic area.



Due to the dynamic environment in real-world applications usually, it is not always best to focus on predicting the exact customer behavior, but rather to find a robust solution that will ensure sufficient profitability, considering different customer behavior models and their possible changes.

Customer Behavior Models: Binary vs. Proportional

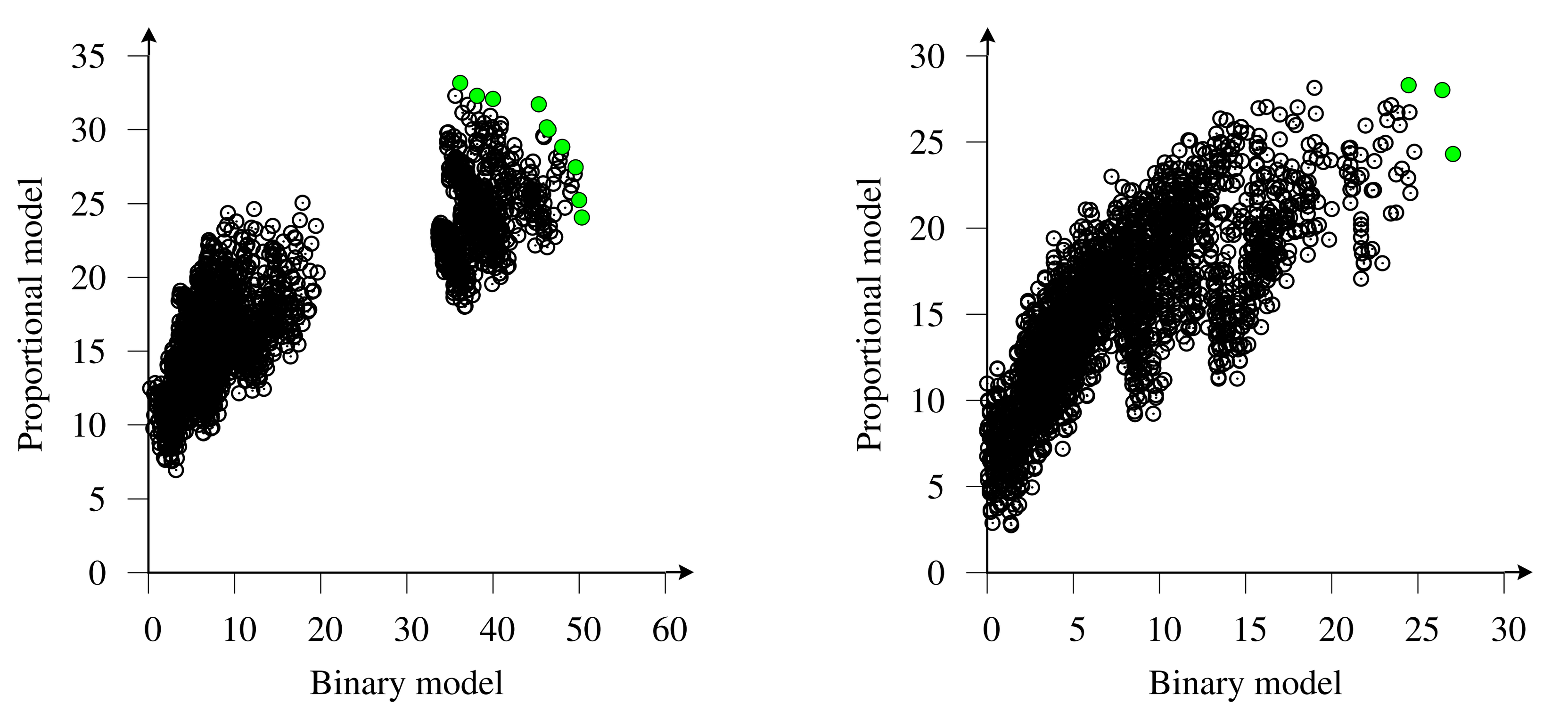


All customers from a single demand point patronize the most attractive facility.

The buying power of a single demand point is split among all facilities in proportion to their attraction

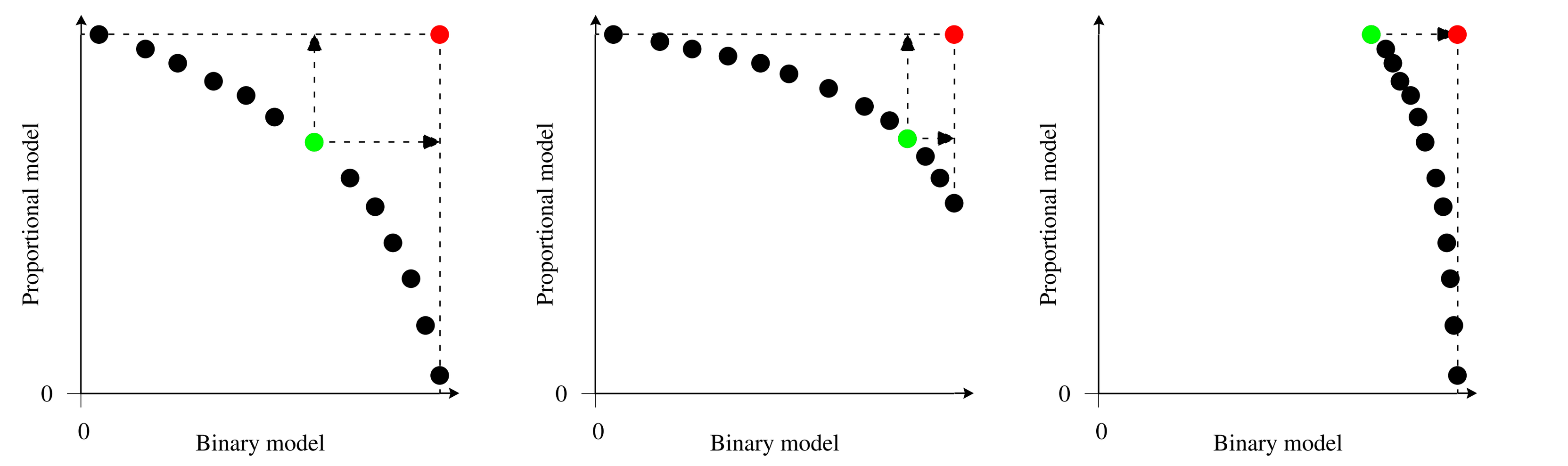
Pareto Optimal Solutions

Illustration of Pareto-optimal solutions for 2 different instances of the discrete facility location problem in the context of all possible solutions obtained using the complete enumeration algorithm.



The best solution for the binary model cannot be considered optimal for the proportional model and vice-versa.

The Knee Point



- Left: market share varies relatively equally across both models, placing the knee point in the middle of the Pareto front.
- Middle: the binary model is notably more sensitive to market share loss and the knee point suggests the decision-maker's focus should be more on maximizing the market share obtained by the binary model.
- Right: the proportional model is more sensitive than the binary model and the knee point suggests choosing the solution that is the best for the proportional model.

Locations for Park & Ride Hubs

The goal is to select the best locations for Park & Ride hubs in Vilnius from a set of predefined potential sites. These hubs will compete with one another for users who choose to park their cars at the hubs and switch to public transport or other forms of sustainable mobility, such as bicycles or scooters, to reach their final destination.

- **Predefined set of location candidates**. There is a finite set of potential locations (discrete points) where the Park & Ride hubs can be located.
- **Competition between hubs**. Each hub competes with other hubs for users. The attractiveness of a hub depends on factors such as proximity to high-traffic areas, connectivity to public transport, convenience, and pricing. Users will choose the hub that minimizes their travel time or cost.
- **Customer behavior and demand**. Demand is influenced by the population density, traffic patterns, and public transport accessibility. The hubs must be placed where the potential demand for Park & Ride services is highest.
- **Capacity limitations**. Each hub has a limited capacity to accommodate vehicles. Overloading one hub can lead to reduced service quality, while underutilized hubs result in inefficient resource use.
- **Budgetary constraints**. There are financial limits regarding the number of hubs that can be established and maintained. This is a constraint on the total number of hubs that can be selected from the set of potential sites.

Methods

- **Discrete Facility Location.** The problem will be described as a discrete facility location problem.
- **Reinforcement Learning** will be used to find optimal locations.
- **Multi-Agent Systems** to handle uncertainties.
- **High-Performance Computing** to process data and solve complex problems.

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