Optimized travel options with a Flexible Mobility on Demand System

FMOD

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Agenda

- Motivation and background
- Concept of FMOD
- Modeling framework
- Simulation experiments
- Conclusions and future directions
Motivation and background

- Personalized services using smartphone apps are emerging for taxi:
  - Uber, Lyft, SideCar, GoMyWay, etc.

- Why not apply similar technologies to also DRT and fixed route public transportation?
Concept of FMOD

- **Real-time** system
- **Personalized** demand responsive system that gives the traveler an optimized menu
- **Dynamic allocation** of vehicles to services

Customer

FMOD server

allocate

Fleet

- taxi
- shared taxi
- mini-bus

request

offer

choose
Concept of FMOD (cont.)

• **Taxi:** Flexible route, flexible schedule, private

• **Shared-taxi:** Flexible route, flexible schedule, shared

• **Mini-bus:** Fixed route, flexible schedule, shared
Concept of FMOD (cont.)

Supply Demand

FMOD Server

Optimization

Request:
Origin: A, Destination: B
Preferred Departure Time: 8:00 – 8:30
Preferred Arrival Time: 8:45 – 9:00

Offer:
taxi: DT: 8:25/AT: 8:45, $20
shared-taxi: DT: 8:27/AT: 8:57, $10
as the 4th passenger
mini-bus: DT: 8:14/AT: 8:59, $5
as the 6th passenger

Choice:
service: shared-taxi
DT: 8:27/AT: 8:57, $10
Modeling framework

• Product
  – A service on a vehicle departing at a certain time period

• Feasible product
  – A product that satisfies the capacity and scheduling constraints
    • Vehicle capacity
    • Existing schedule
    • Preferred time window
      – Maximum schedule delay

• Offer
  – A list of feasible products presented to the customer (max 1 product for each service)
Phase 1. Feasible product set generation
Set of feasible products to be offered to the customer taking into account:
- Capacity constraints
- Scheduling constraints based on the request

Phase 2. Assortment optimization
Optimized list to be offered to the customer from the feasible set
- Maximize operator’s profit and/or consumer surplus based on a choice model
Assortment optimization model

- Optimizes the list to be offered to each customer request among all the feasible products
- Choice model is integrated into the optimization model in order to represent shares of services
- Formulated as a mixed integer linear problem
- Myopic vs dynamic

Different versions of the model are considered:
- maximize consumer **surplus** (logsum)
- maximize **profit**
- maximize profit + consumer surplus: **total benefit**
Simulation experiments

Case study

- Simulation time: 24 hours
- Network
  - Hino city in Tokyo (approx. 9km×8km)
- Supply
  - Fleet size: 60
  - Bus line: actual route
- Demand
  - 5000 requests / day
  - OD: station, hospital etc. (population density)
  - VOT: from $6/h to $30/h
- Fare
  - Taxi: $5 (base) + $0.5 (per 320m)
  - Shared-taxi: 50% of taxi fare
  - Bus: $3 (flat)
- Operator Cost
  - $200 / day / vehicle + $0.2 per km

(Yellow: Bus line)
Simulation experiments

Snapshots

Red: Taxi, Green: Shared taxi, Blue: Mini-bus, Yellow: empty

Off-peak (AM 6:00)
Taxi is dominant

Peak (AM 8:00)
Shared taxi / Mini-bus are dominant
Simulation experiments

Comparison of models

T: taxi, S: shared-taxi, B: mini-bus
Simulation experiments

Main findings

- The offer given by FMOD is significantly affected by the objective function.

- Total benefit case compared to profit maximization:
  - Significant increase in consumer surplus without much decrease in profit

- Dynamic allocation of vehicles provides significant improvements over static allocation
Conclusions and future directions

• FMOD has a potential to increase operator’s profit and improve passenger satisfaction

• Ongoing and further research directions include:
  – Field test
  – Estimation of future demand
  – Real life conditions (e.g. traffic)
  – Learning the behavior of customer through repeated visits
Thank you for your attention!

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