Carpool-based Parking Assignment Policy

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Outline

- Research Objectives
- Motivation
- Previous Work
- Model Formulation and Heuristics
- Exploring Parking Policy Preferences
- System Prototype
- Future Research Directions

Objectives

- Develop an equitable strategy to mitigate parking scarcity and mobility problems
  - Develop mathematical models to implement the strategy
  - Analyze public perception of the strategy
  - Test the strategy in the real-world
Motivation

- The “lack” of parking spaces has caused problems at UPRM
Not a Unique Situation

- **Cruising for parking**
  - A non-trivial proportion of urban traffic can be explained by people searching for parking
  - An inefficient use of resources with a high economic, environmental, and public health cost

What can we do?

- Land Use Planning
- Operations Management
- Rule/Law Enforcement
- Encouraging Carless Travel
- Increasing Parking Capacity
Parking Demand Management

- Goal is to reduce or shift the demand for parking

- Voluntary (Carrot)
  - Carpooling incentives
  - Incentives for carless travel

- Mandatory (Stick)
  - Parking pricing
  - Parking allocation system

- Shifting Activity Participation
  - For example, shift class schedules

Parking Pricing

- “Cities should charge the right prices for curb parking because the wrong prices produce such bad results” (Shoup 2011)

- Pricing is a popular strategy among transportation economists, engineers, and planners, among others

- Major parking pricing projects have been launched in recent years (e.g., SFpark)
The Challenges with Parking Pricing

- There are at least two major problems with pricing:
  - Political opposition (political context)
  - Equity concerns (social context)
- These are not unsurmountable problems
- Parking pricing might be regressive, but the other financing alternatives might be as (or more) regressive than pricing parking

Application Context of Proposed Strategy

- Strategy should be most relevant for communities with:
  - Limited public transportation options
  - High proportion of low-income community members
  - Low population density
  - High concentration of activities (e.g., universities)
- No pricing, carpool-based parking assignment
  - Carpools as substitute for public transportation
Related Work

Contribution

- New travel demand management strategy
- Proposed model can be considered an extension to static ride-matching problems that assume:
  - flexible customer roles (i.e., drivers or riders)
  - multiple rider pick-ups (1-to-many matching)
  - guaranteed ride-back trips
Previous Peer-to-Peer Ride-Matching Work

- Previous ride-sharing models consider (Tafreshian et al., 2020):
  - transit service transfers,
  - pricing schemes and the use of HOV lanes, and
  - rider transfers between drivers, among other issues
- To our knowledge, our model is the first in the literature to account for parking considerations

Non-pricing Parking Management

- Two broad categories:
  - Static systems with cyclical allocation of parking slots
  - Dynamic systems for real-time parking slot allocation
- Example: Goyal and Gomes (1984)
  - Linear programming model to allocate permits among different individual in university context
  - Objective: minimize total walking distances from parking lots to final destinations
Non-pricing Travel Demand Management

- Examples:
  - Highway access booking systems (Edara & Teodorović, 2008; Ma et al., 2010; Liu et al., 2013)
  - Downtown space reservation systems (Zhao et al., 2010)
  - Tradable permits for road access (Fan & Jiang, 2013)

Model Formulation and Heuristics
Proposed Solution: Parking Allocation and Ride-Sharing System (PARS)

- Centralized system to allocate parking and coordinate carpools

PARS:

- Selected Drivers and Carpools
- Selected Parking Reservations

PARS: General Mathematical Formulation

Maximize Social Objectives

Subject to
- Parking Capacity Constraints
- User Schedule Constraints
- Vehicle Capacity Constraints
- Other Considerations
Problem

▪ The goal is to minimize a measure of generalized cost

▪ For details, see:

Heuristics

▪ Ride Decomposition (RD):
  • decomposition-based heuristic that first solves a sub-problem associated with going to the venue, and given that solution, it solves the sub-problem associated with returning from the venue

▪ Quick Converge (QC):
  • finds minimum-cost solutions and manipulates them to consider parking capacity restrictions.
Numerical Experiments

- RD and QC heuristic algorithms can:
  - solve the problem, on average, 42.23% and 86.39% faster than a commercial solver
  - find solutions that are 3.61% and 3.49% from optimal, respectively.

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Exploring Parking Policy Preferences
Survey

- Survey explored:
  - factors that influenced people’s preference for PARS vs. parking pricing
  - People’s stated comfort with giving a ride to or traveling with strangers
- Number of participants:
  - UPRM: 456
  - USF: 261

Context of Parking Situations

- UPRM:
  - Permit system based on community member classification
  - Distributed free from out-of-pocket cost
- USF:
  - Community members must buy permits
Stated-Preference Questions

Discrete Choice Analysis

- Multinomial logit models estimated using data from stated-preference questions

Estimated Parameters for Parking Choice Model – Sociodemographic Attributes

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<th>Variables</th>
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Discrete Choice Analysis

Estimated Parameters for Parking Choice Model – Alternative Attributes

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<td># of passengers</td>
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<td>Added travel time – carpooling (minute units)</td>
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<td>Location: Parking cost</td>
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Comfort with Carpooling

“I would be comfortable with giving a ride to a fellow student as part of a university coordinated carpooling program.”

![Comfort with Carpooling Chart]
Comfort with Carpooling

“I would be comfortable with being a passenger in a university coordinated carpool”

Prototype and Future Directions
Prototype at UPRM

- Reservation Optimized Carpool System

Prototype Components

- **Hardware:**
  - Solar-powered parking mechanical arm to control

- **Software:**
  - ROCS Carpool app
    - Geolocation-based approach to verify that selected carpool members are in vehicle
    - Currently working on various types of app notifications
System Launch

- System tests and improvements are currently being conducted
- Launch should be late October or early November 2023
- Know unknowns and unknown unknows
  - For example, will people try to game the system?
- Surveys to assess user experience
Future Research Directions

- Development of hybrid pricing – PARS
  - To support revenue generation
- Faster heuristics
- Optimize the operations of ROCS
  - Student project with funds from Toyota Puerto Rico

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- Questions:
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Referencias


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