Order Dispatching in Ride-Sharing Platform under Travel Time Uncertainty: A Data-Driven Robust Optimization Approach (Paper ID: 40)

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Presented by: Xiaoming Li
➢ Introduction to Ride-Sharing in Mobility on Demand Systems
➢ Problem Description
➢ Methodology and Formulation
➢ Experimental Results
➢ Conclusions and Future Work
Introduction to Ride-Sharing in Mobility on Demand Systems

- Ride-sharing platforms such as Uber, Lyft, and Didi have reshaped the transportation mode.
- Ride-sharing is a transportation mode where the travelers have similar itineraries in mobility on demand systems.
- Merits and advantages for both riders (demand side) and drivers (supply side). Reduce cost by sharing, reduce traffic congestion by decreasing fleet, etc.

Source: https://disrupt-africa.com/2016/12/20/ride-sharing-platform-gawana-to-launch-in-rwanda/
Introduction to Ride-Sharing in Mobility on Demand Systems

Problem Description

Methodology and Formulation

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Problem Description

- A set of drivers, a set of riders, and a central operator for the ride-sharing platform
- Travelers (drivers / riders) claim their origins and destinations (coordinates) as well as their earliest departure times and latest arrival times
- Travel time is considered under uncertainty
- One-to-one matching to find the optimal solutions such that the overall travel time savings is maximized under worse-case scenario (maximum travel time delay)
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Methodology and Formulation

- Robust optimization. To maximize the overall travel time saving under worst-case scenario (maximum travel time delay), while a group of constraints must be satisfied.

- The construction of uncertainty set. The nominal travel time and travel time deviation are assumed to be time-series data. Therefore, time-series forecasting approach (ARIMA in this work) is introduced.

\[ U_1 = \{ \xi \mid \| \xi \|_1 \leq \Gamma \} = \left\{ \xi \mid \sum_{j \in J_i} |\xi_j| \leq \Gamma \right\} \]

- The derived uncertainty set will be used as the input for the robust optimization model.
Methodology and Formulation

\[
\max \sum_{d \in \mathcal{D}^k} \sum_{r \in \mathcal{R}^k} \left( \bar{T}^0_{d,r} x_{d,r} + \min_{\xi \in \mathcal{U}} \xi_{d,r} \bar{T}^0_{d,r} x_{d,r} \right) \tag{2}
\]

s.t.

\[
\bar{T}^0_{d,r} + \min_{\xi \in \mathcal{U}} \xi_{d,r} \bar{T}^0_{d,r} + H(1 - x_{d,r}) \geq 0, \forall d \in \mathcal{D}^k, \forall r \in \mathcal{R}^k, \tag{2a}
\]

\[
dt_d \geq cs(d), \quad \forall d \in \mathcal{D}^k, \tag{2b}
\]

\[
dt_d + \bar{T}_{o(d),o(r)} + \min_{\xi \in \mathcal{U}} \xi_{o(d),o(r)} \bar{T}_{o(d),o(r)} + H(1 - x_{d,r}) \geq cs(r), \forall d \in \mathcal{D}^k, \forall r \in \mathcal{R}^k, \tag{2c}
\]

\[
dt_d + \bar{T}_{d,r} + \min_{\xi \in \mathcal{U}} \xi_{d,r} \bar{T}_{d,r} \leq la(r) + H(1 - x_{d,r}), \quad \forall d \in \mathcal{D}^k, \forall r \in \mathcal{R}^k, \tag{2d}
\]

\[
dt_d + \bar{T}_{d,r} + \min_{\xi \in \mathcal{U}} \xi_{d,r} \bar{T}_{d,r} \leq la(d) + H(1 - x_{d,r}), \quad \forall d \in \mathcal{D}^k, \forall r \in \mathcal{R}^k, \tag{2e}
\]

\[
\sum_{r \in \mathcal{R}} x_{d,r} \leq 1, \quad \forall d \in \mathcal{D}^k, \tag{2f}
\]

\[
\sum_{d \in \mathcal{D}} x_{d,r} \leq 1, \quad \forall r \in \mathcal{R}^k, \tag{2g}
\]

\[
x_{d,r} \in \{0,1\}, \quad \forall d \in \mathcal{D}^k, \forall r \in \mathcal{R}^k, \tag{2h}
\]

\[
dt_d \in \mathbb{R}_+, \quad \forall d \in \mathcal{D}^k, \tag{2i}
\]
Outline

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Experimental Results

- Experiment setup. Python 3.7, Gurobi 9.0, Intel Core i7 CPU, 32 GB RAM, Win 10
- Data sets. New York taxi trip records, January 2017 – June 2017. Seven regions and six time slots are selected.

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The comparison of average travel time savings

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The comparison of violation rates

- The metric to measure the robustness of solution (the unmatched rates of rider)

Fig. 3: Comparison of violation rates by data-driven robust optimization and non-data-driven robust optimization
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Conclusions and Future Work

- **Conclusions.** We propose a data-driven robust optimization approach to address order dispatching in ride-sharing platform. The framework organically integrates time-series predictor and robust optimization model.

- **Future work.**
  - To extend one-to-one driver and rider matching to one-to-many matching (i.e., one driver can pick up more than one rider).
  - To utilize different types of uncertainty sets to validate the performance of robust optimization models.
Thank you!

Questions?