Integrated operator and user-based rebalancing in dockless shared e-micromobility systems

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Overview

- ❑ Introduction and background
- ❑ Types of bike sharing systems
- ❑ Challenges
- ❑ Problem description and methodology
- ❑ Results

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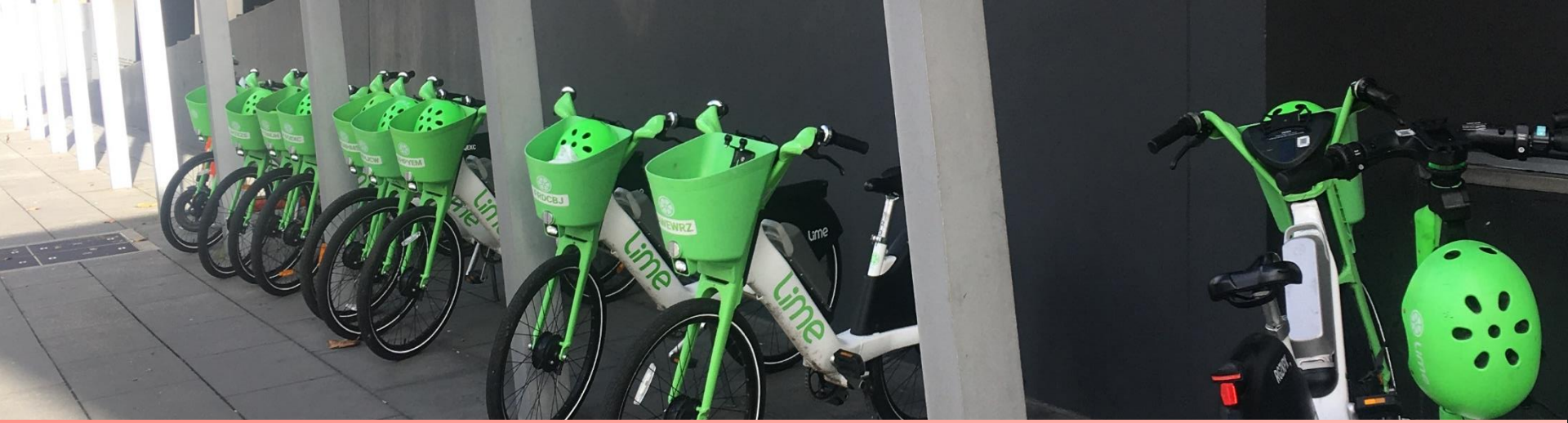

Introduction of shared micromobility systems

Bike-sharing systems (BSS)

- To serve first and last mile needs in multimodal transport networks
- Eco-friendly, a low-carbon and sustainable mode of transportation

Technology of Internet of Things (IoT)

- Operators uses real-time data, improves the overall service quality for users

Electric bikes and scooters are more appealing

- Enhanced convenience
- Higher speeds

Station-based shared e-micromobility systems

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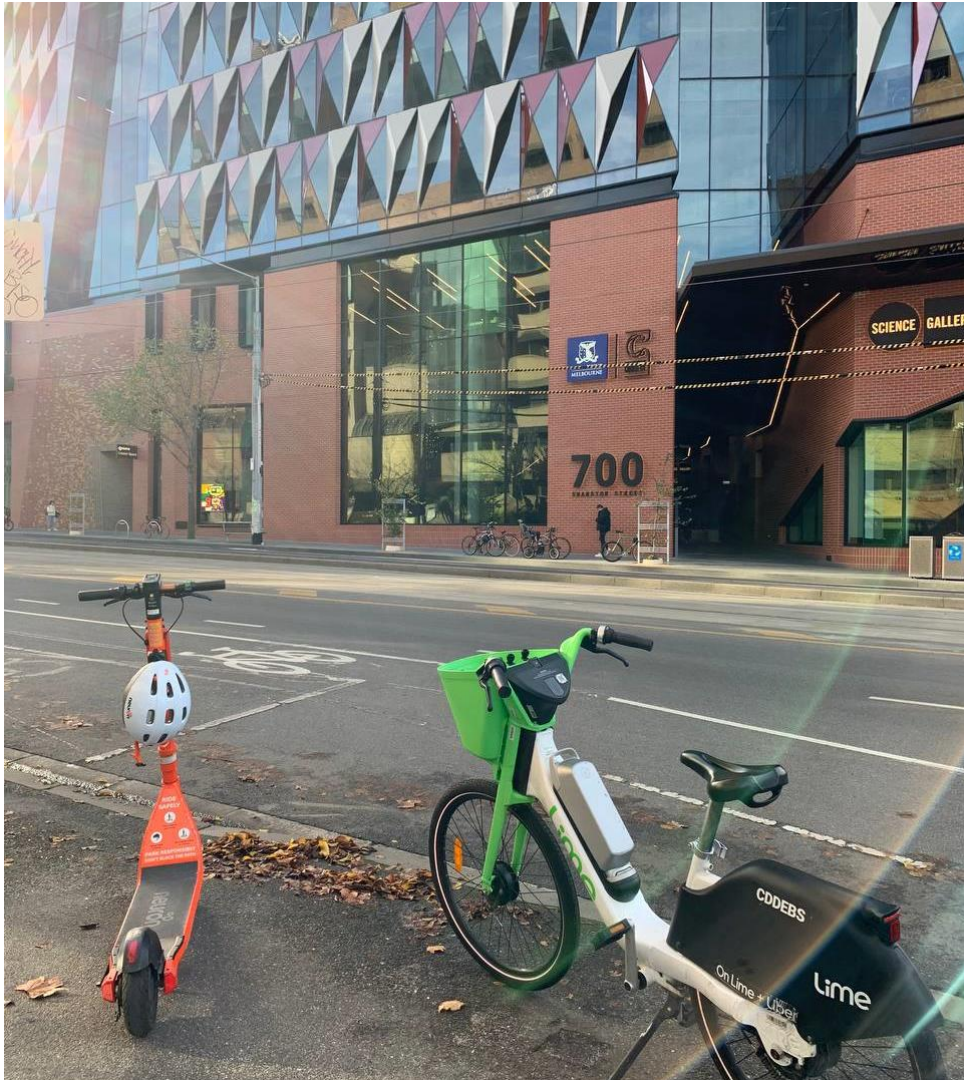
Dockless shared e-micromobility systems



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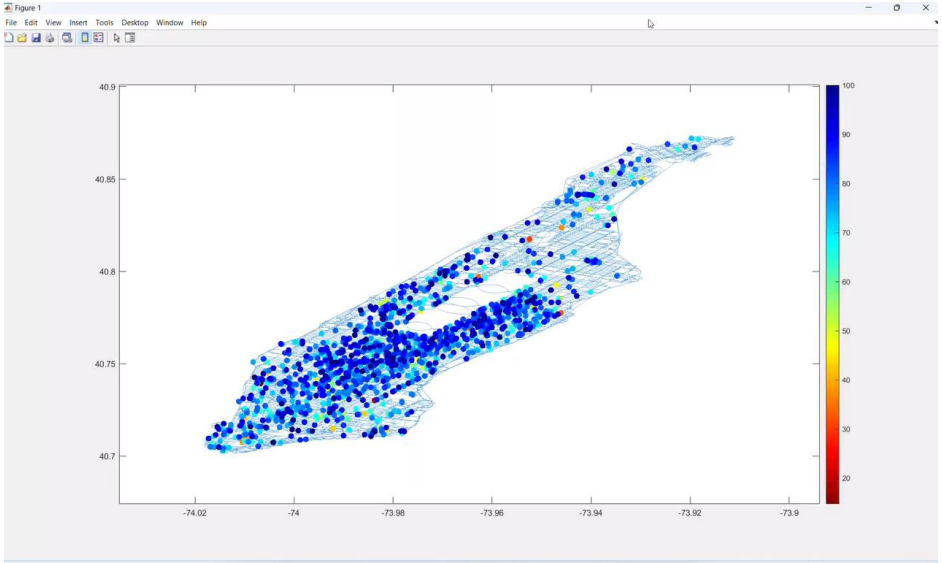
Bike imbalance problem



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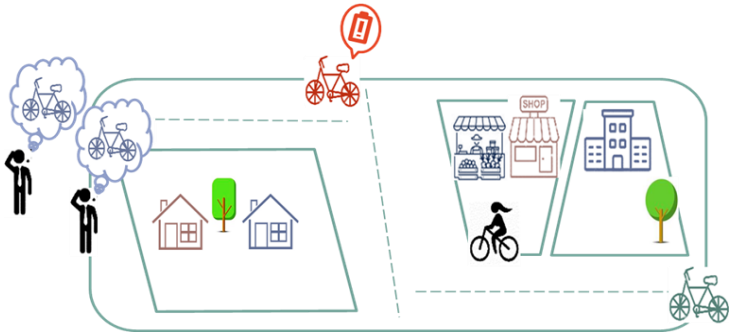

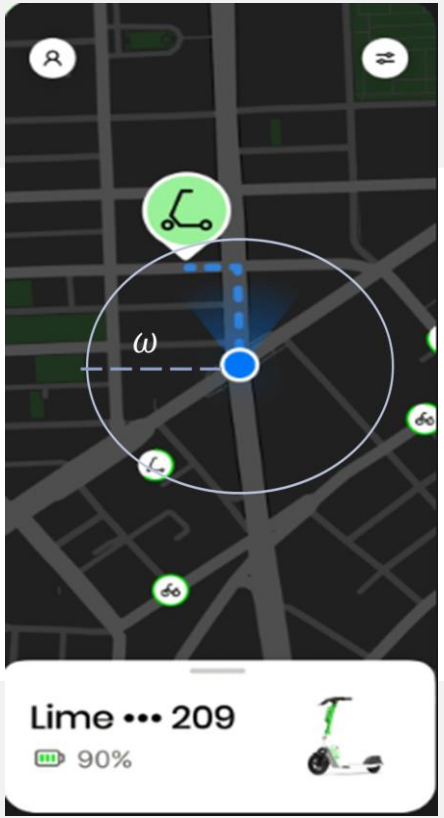

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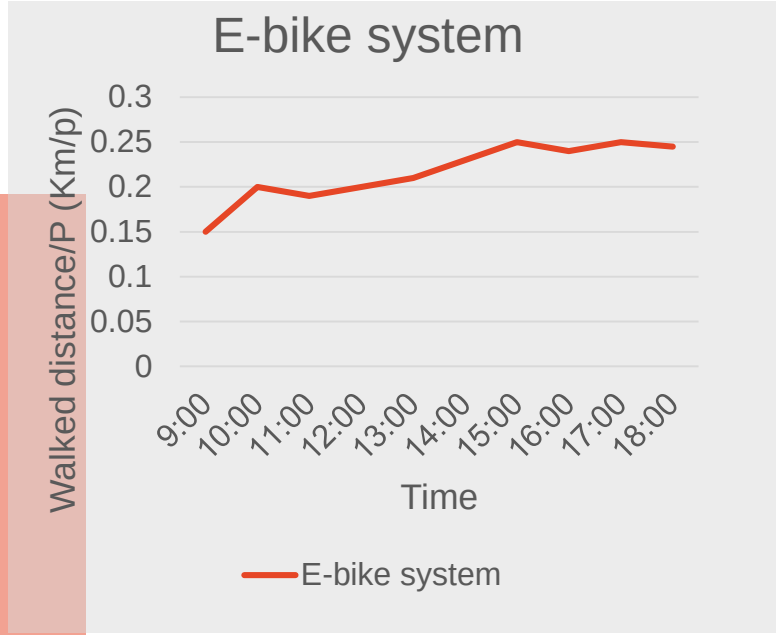
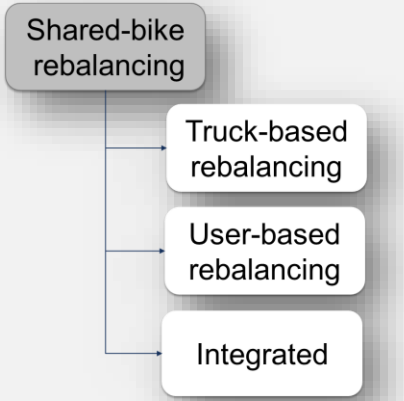
- Longer walking distance for users to pick the reserved bikes up
- More cancellation rate



Methodology



Mixed binary rebalancing problem

- Aims to minimize cost function (minimize cost & maximize benefits)

$$\underbrace{\sum_{q}\sum_{i}\sum_{j} \mathrm{c}\, d_{ij}\, y_{ij}^{q}}_{\text{Truck routing}} + \underbrace{\sum_{q}\sum_{i}\sum_{j} \mathrm{s}\, x_{ij}^{q}}_{\text{Operator-based rebalancing cost}} - \underbrace{\sum_{q}\sum_{i}\sum_{j} \alpha\, (l_{\text{full}} - l_i) x_{ij}^{q}}_{\text{Operator-based rebalancing benefit}} + \underbrace{\sum_{i}\sum_{j} r_{ij}\, z_{ij}}_{\text{User-based Rebalancing cost}} + \underbrace{\sum_{j} p_j |D_j - F_j|}_{\text{Demand satisfaction}}$$

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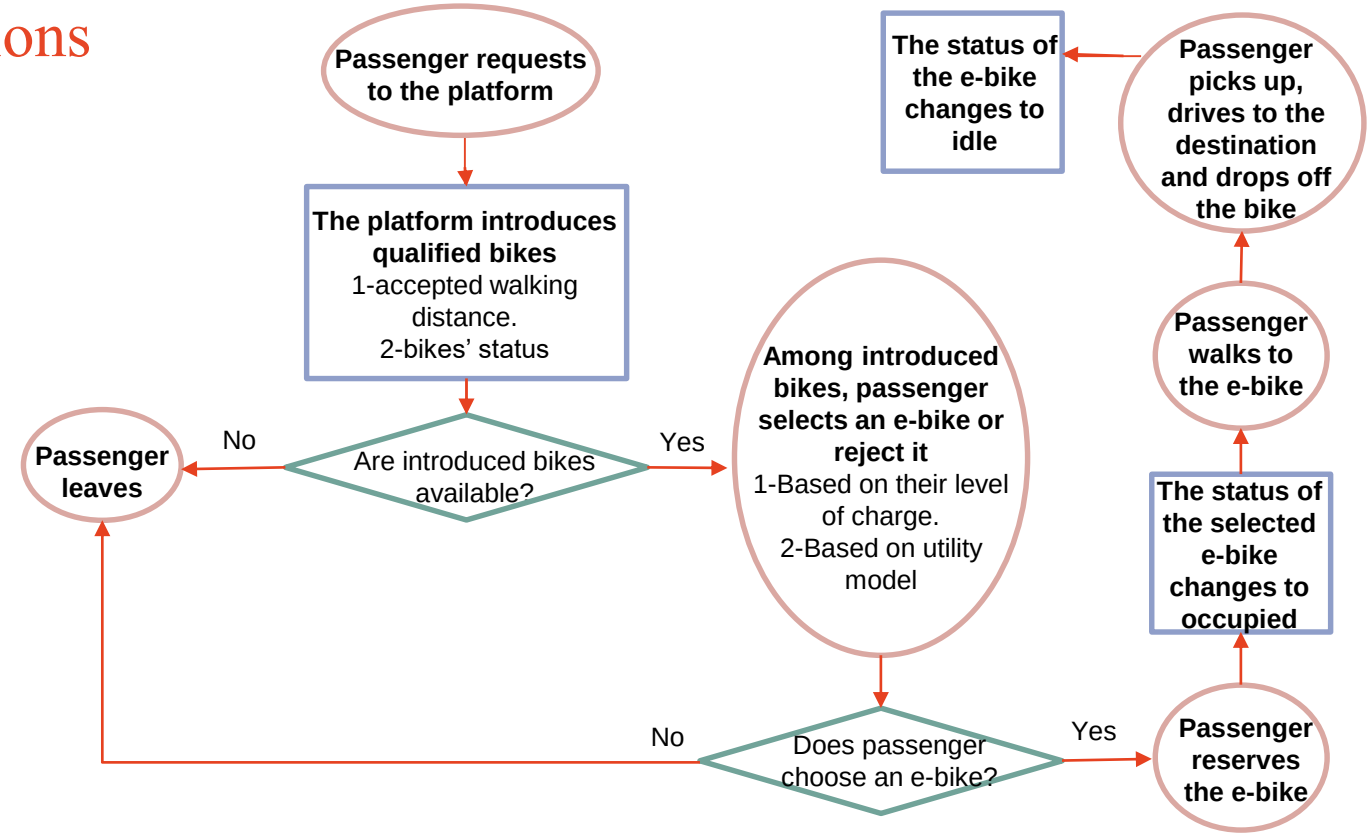
Notations

Decision variables	description
x_{ij}^{q}	Decision variable for truck-based rebalancing.
y_{ij}^{q}	Decision variable for routing of trucks
z_{ij}	Decision variable for user-based relocation.

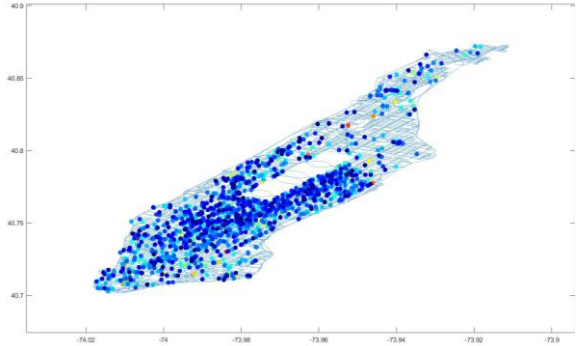
variables	Description
d_{ij}	Distance of Node i to Node j
l_i	Level of charge of bike located in Node i
r_{ij}	Reward of user-based rebalancing
F_j	Final bike inventory
D_j	Predicted bike demand in the next time step
p_j	imbalanced penalty at node j

constants	description
c	Unit travel cost of balancing trucks
s	Unit battery swapping cost
α	Level of charge to rental fee conversion factor
l_{full}	Level of charge of a full charged battery

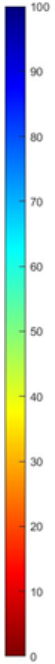
Interactions

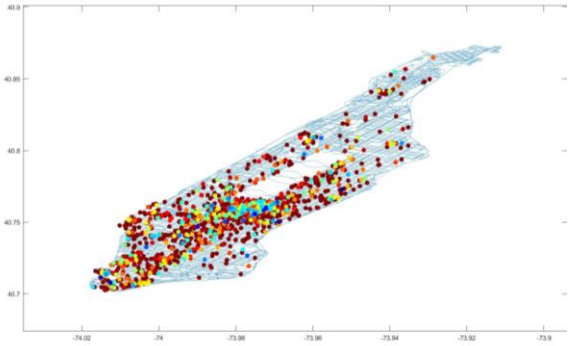


Results comparison

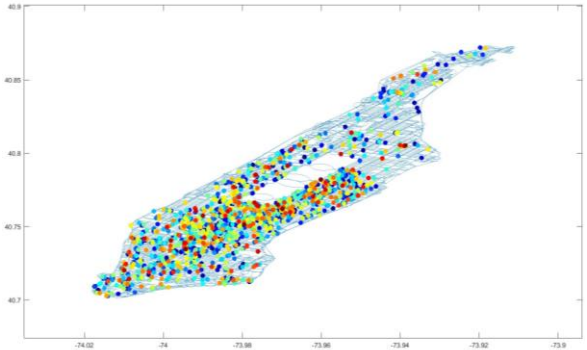


E-bike sharing system 09:00



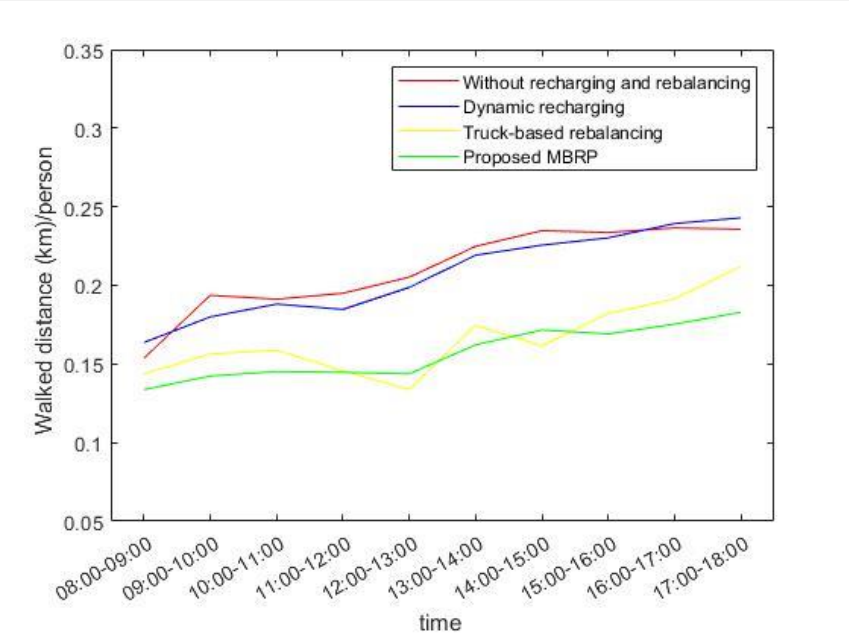


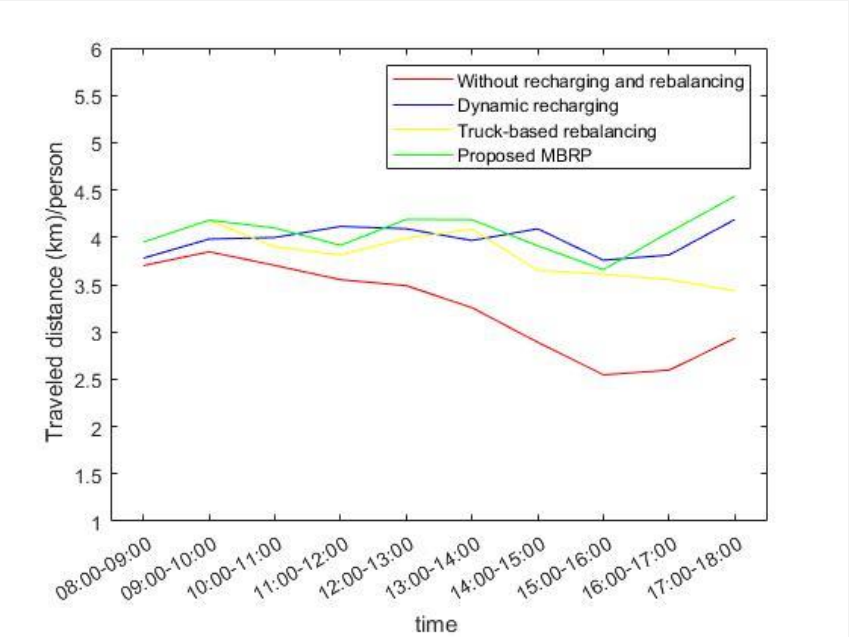
Not charging not rebalancing 18:00



Proposed integrated method 18:00

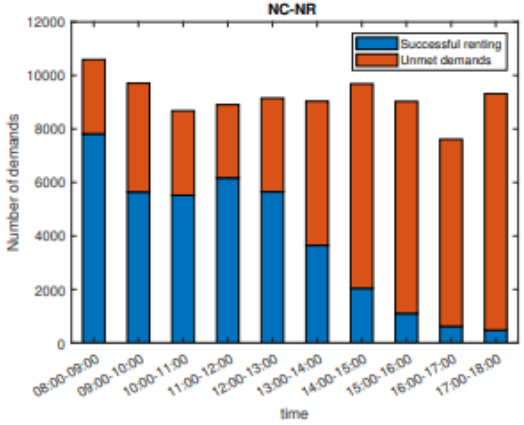
Numerical experiments and metrics

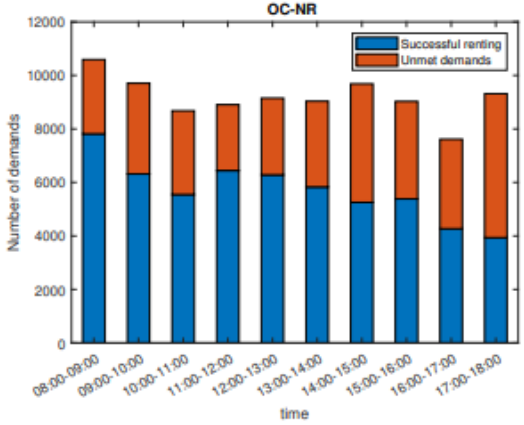


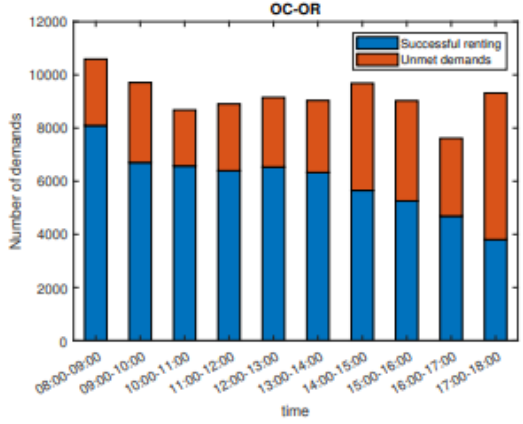


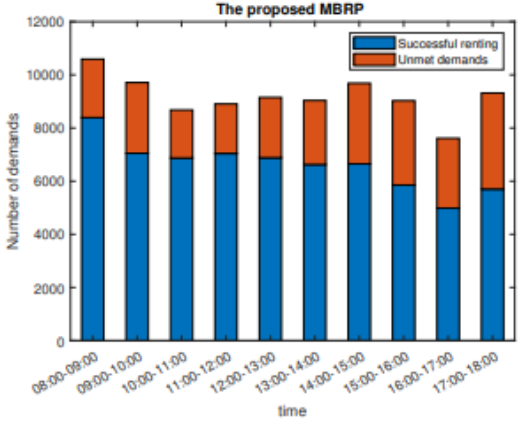
Number of unmet f=demand

Number of successful demand









Thanks for your attention

Questions?

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