Balancing of Truck Parking Demand by a Centralized Incentives/Pricing System

Filipe Vital

Advised by

Prof. Petros Ioannou

Department of Electrical Engineering

University of Southern California

December 3, 2021

Significance – Trucking Industry

- $700B industry in the USA
- Cargo Thefts: € 8.2 billion per year in the E.U.[2]
- 50,000+ injury crashes in 2017[3].
- Accident payouts above $10 million are increasing[4].
- Companies are closing due to insurance costs.

1. Boris, C. & Brewster, R. A Comparative Analysis of Truck Parking Travel Diary Data. Transp. Res. Rec. J. Transp. Res. Board 2672, 242–248 (2018).
2. Weenen, R. de L. van et al. Study on Safe and Secure Parking Places for Trucks. (2019). doi:10.2832/067535
3. USDOT. Large Truck and Bus Crash Facts 2017. Fed. Mot. Carr. Saf. Adm. (2019).
4. Smith, J. Surging Truck Insurance Rates Hit Freight Operators. Wall Street Journal (2020).

Top Issue in Trucking

Number 1: Driver Shortage

Top Reasons: (tie) Driver Compensation and Truck Parking

The American Truck Parking Shortage

Survey conducted on Interstate 5, a California highway, 70% of drivers found that truck stops were full and had to keep going.

4,000 drivers were surveyed in 2013 and found that:

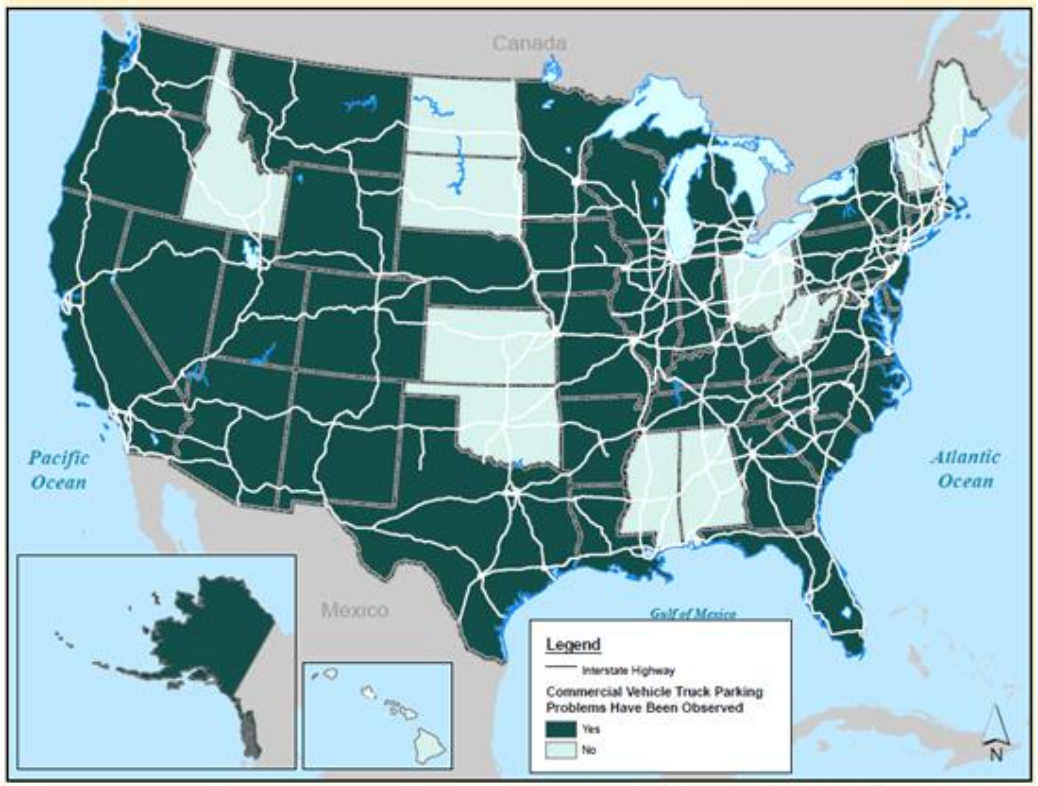
- **40% spend over an hour on average to find night parking**
- **28% regularly or occasionally stay on freeway ramps**
- **52% pull up behind shopping centers**
- **45% hunt for places like abandoned gas stations/vacant strip malls.**

Source: https://www.alltruckjobs.com/blog/roadbreakers-app-overnight-parking-finder/

Context

- **Many drivers report issues to find truck parking at night.**
- **Less than 50% of truck stops report operating overcapacity at night.**

Too many trucks going for the same rest areas at the same time!!!



States Reporting Truck Parking Problems (dark green) *[Source: Jason's Law Truck Parking Survey Results and Comparative Analysis]*

Current Problems with Long-Haul Trucking

- **Hours of Service (HOS) Restrictions: Increase demand for parking when needed**
- **Parking infrastructure cannot always cope with the demand when needed**
- **Optimizing individual's truck's path and parking availability may not solve the system problem that involves all trucks and infrastructure**
- **Illegal parking is on the increase leading to safety issues and increase pollution and costs and Driver frustrations.**
- **What is needed is an overall system approach to do the planning scheduling and routing of trucks in order to minimize an overall system cost**

Truck Parking Apps

1. Trucker Path
2. Road Breakers
3. Park My Truck
4. Truckbubba
5. DAT Trucker

Parking Information and Appointment System may help but cannot not solve the problem

Current Practices

Based on recent surveys (Martin & Shaheen 2013; Rodier et.al. 2010, US DOT 2015)
most drivers use unauthorized parking locations at least once a week

Most drivers spend more than 30 minutes looking for parking (ATRI, 2018; NCDOT 2017) or park one hour earlier

Paradox: Less than 50% of truck rest places reported working overcapacity

Reported difficulties with parking are during period 7pm-5am

Solution: Increase capacity or decrease demand during peak times

Conclusion: Need a system approach to achieve balancing parking across time and space so the overall system and users benefit by utilizing available capacities

Previous Projects: Plan single truck's long haul trip using HOS and parking availability as constraints.

- Did not consider how each driver's individual solution will affect the overall system and parking availability
- Approach works if number of drivers is small

Conclusion: We need a centrally coordinated system to perform a system level optimization .

Problem 1:

- Large number of drivers will affect what was initially assumed as parking availability and travel times if happened to be given similar routing instructions for same OD and parking locations during closely overlapping time slots
- What was initially assumed to generate the decisions has changed by the decisions

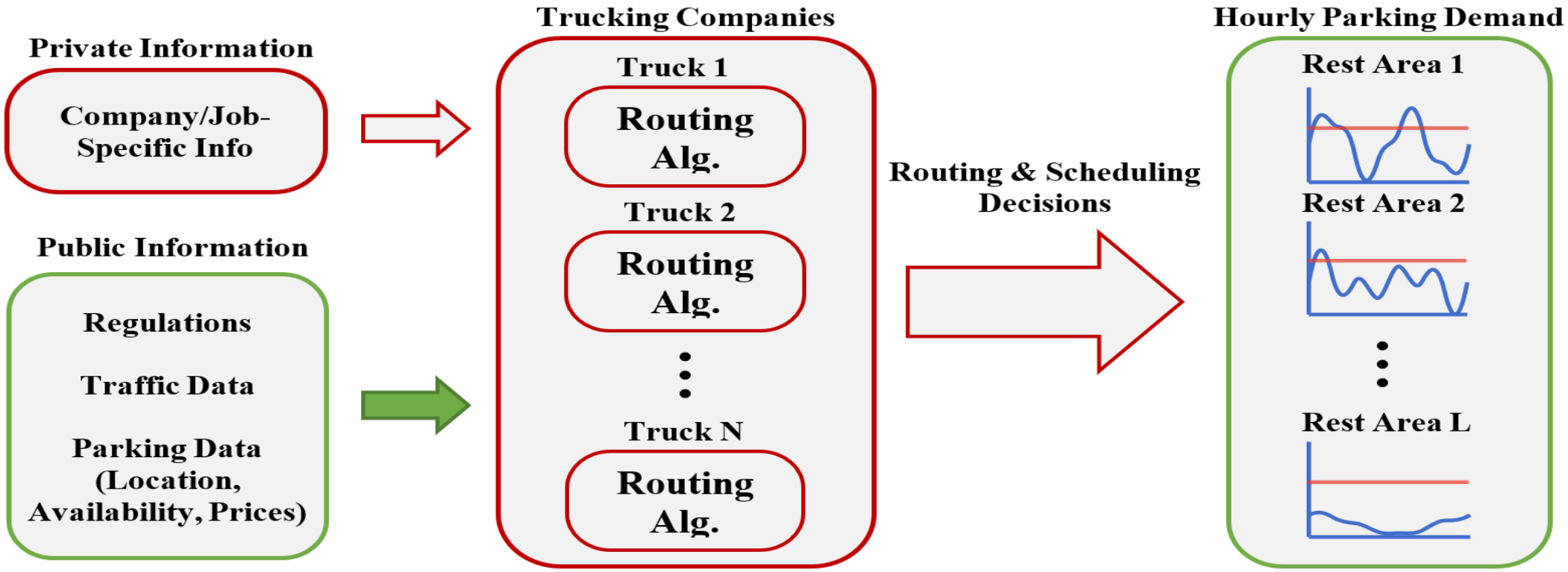
Problem 2

System optimality does not imply user optimality hence the need for using pricing so individual user cost Incurred by a system solution does not exceed that of individual user in the uncoordinated case

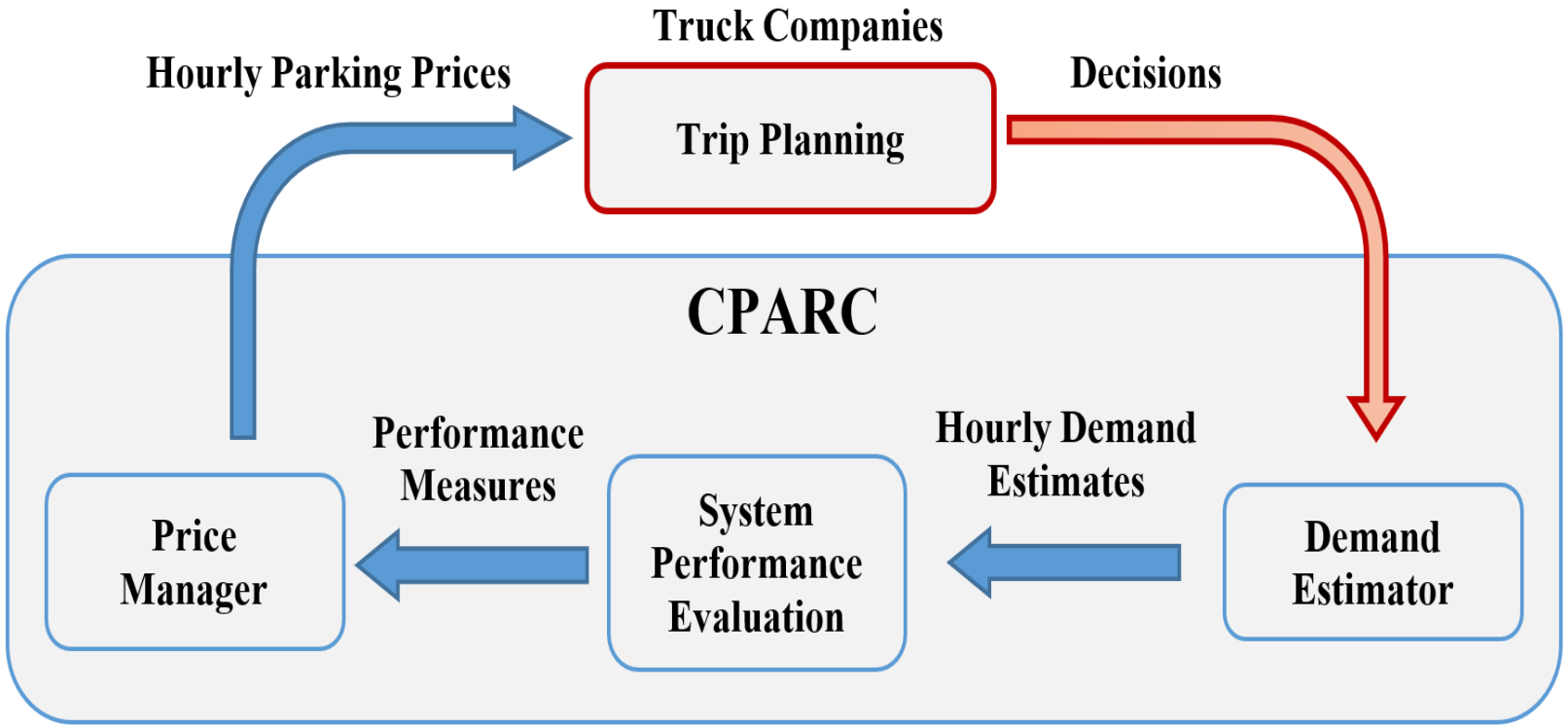
Summary of Approach

- We assume each driver is choosing routes and parking by minimizing an overall cost under certain constraints. The overall cost includes parking cost
- Parking rates depend on both time slot and location
- Each truck is identified by an origin, destination, departure time, delivery time, initial state based on HOS regulations and an hourly operational cost
- Penalties regarding parking difficulties at some locations and times are treated as parking costs.
- The central coordinator changes the parking costs dynamically based on expected demand in an iterative manner till all overcapacity issues are removed
- Use simulations and different scenarios to evaluate the impact of pricing on truck driver decisions assuming they are all going for the least cost solution.

Generation of Parking Demand



Central Parking Coordinator (CPARC) System



Iterative approach till system decisions converge by reducing overcapacity demands

Challenges for Evaluating CPARC

One of the challenges is estimating planners' reactions to price changes so that appropriate prices can be determined.

We use models for the Truck Driver Scheduling Problem to simulate planners' behavior by assuming that the objective of each planner is to minimize its overall cost, part of which is associated with the parking cost.

By changing the parking cost at a particular location, the overall cost may no longer be optimum when compared with a lower cost parking, which may require the planner to modify the initial route.

Parameters unique to each planner, such as client locations, delivery constraints and driver hourly wage, can be sampled from a given distribution, whereas parameters such as travel time, parking locations, parking price and HOS regulations are the same for all planners.

Performance Measures

	$E_i(t) = \max(0, D_i(t) - C_i)$	(1)
	$\Delta_i = \int_0^\infty E_i(t)dt$	(2)
	$\Delta = \sum_i \Delta_i$	(3)

Di(t)= parking demand at facility i at time t

Ci = parking capacity at location i

Ei(t)= measures the excess demand at location i

Δi is a measure of parking shortage at location i measured in parking spaces.hours

Δ= total parking shortage in all locations. When Δ=0 no parking facility has a demand that exceeds capacity

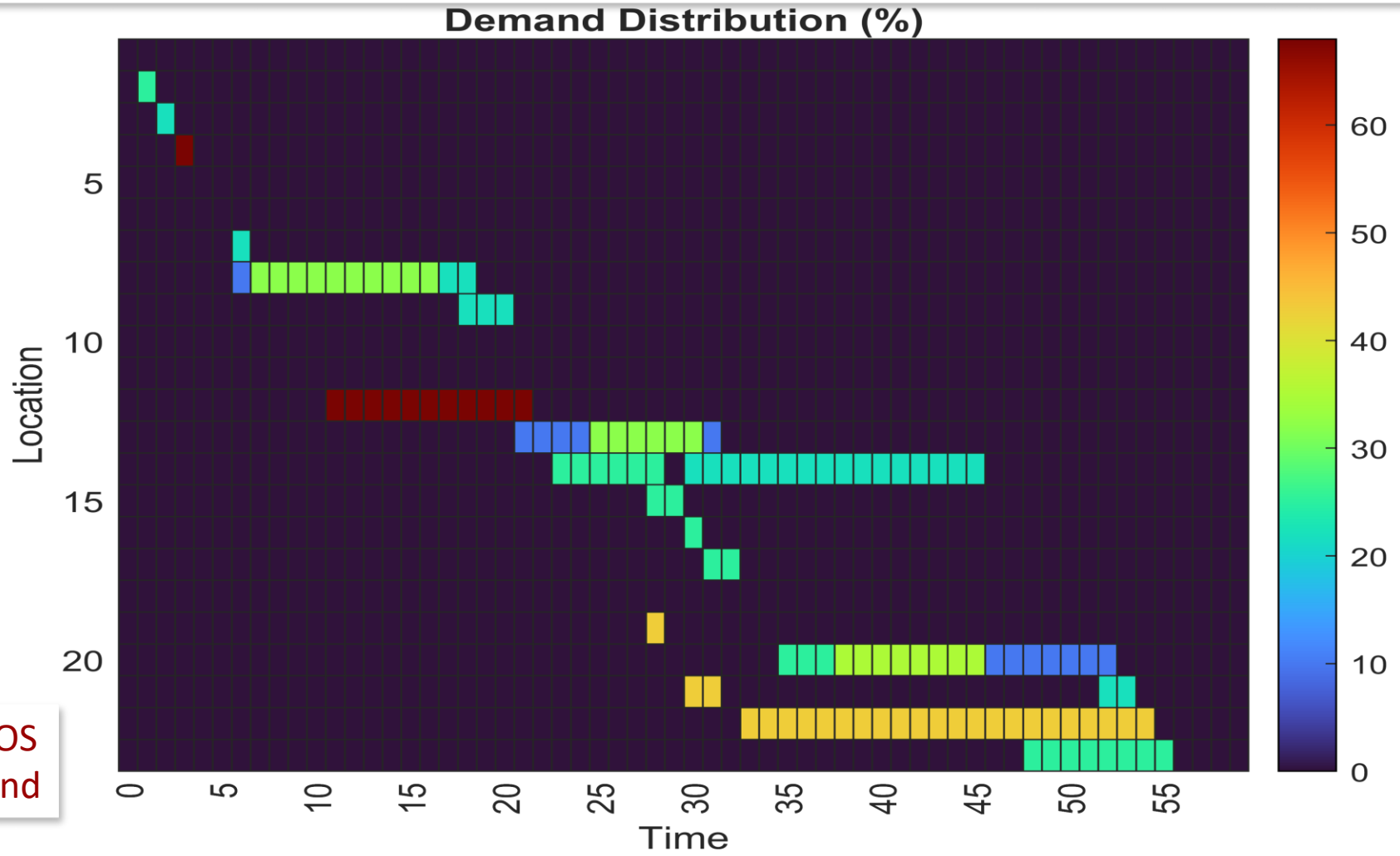
Modified Truck Driver Scheduling Problem (TDSP) under parking and HOS Constraints

MIP Optimization Problem of each planner: Minimize total Cost

Subject to : HOS regulations
Parking Availability

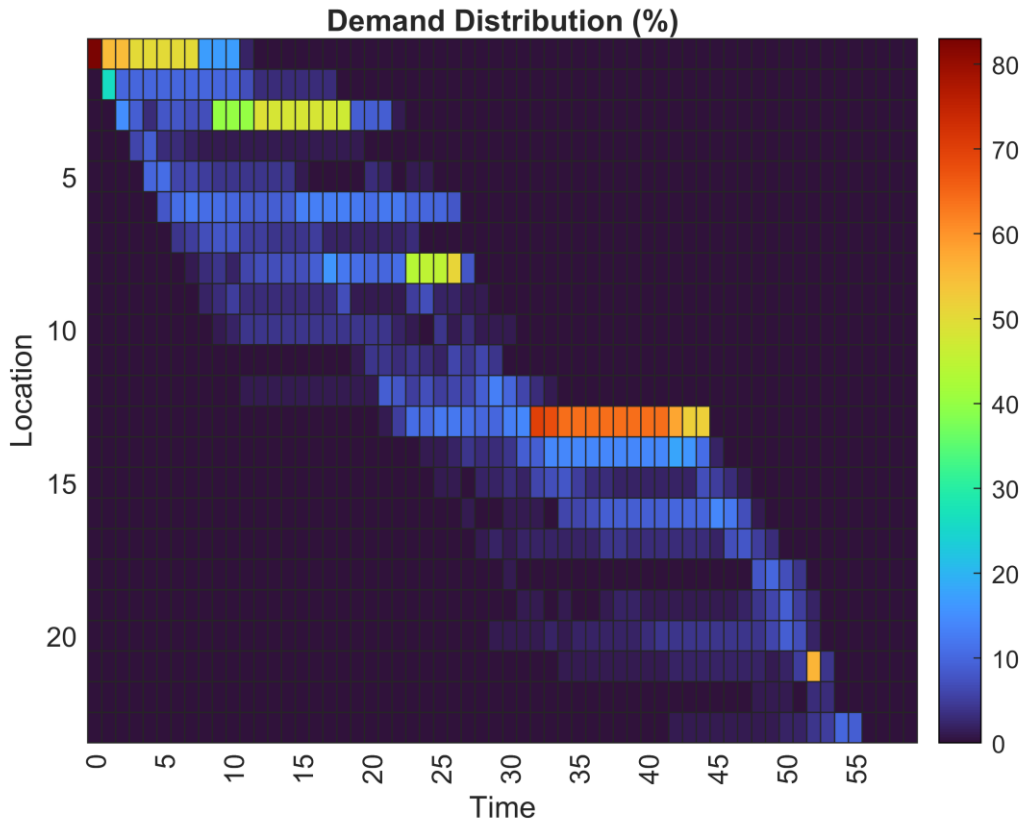
Time horizon is divided into time slots . Each time slot at each parking location has a cost

Simulation results for 100 vehicles with same OD and Departure /Delivery Constraints.
23 h driving time with parking locations 1h apart. HOS initial conditions vary {0,1} and no parking charges

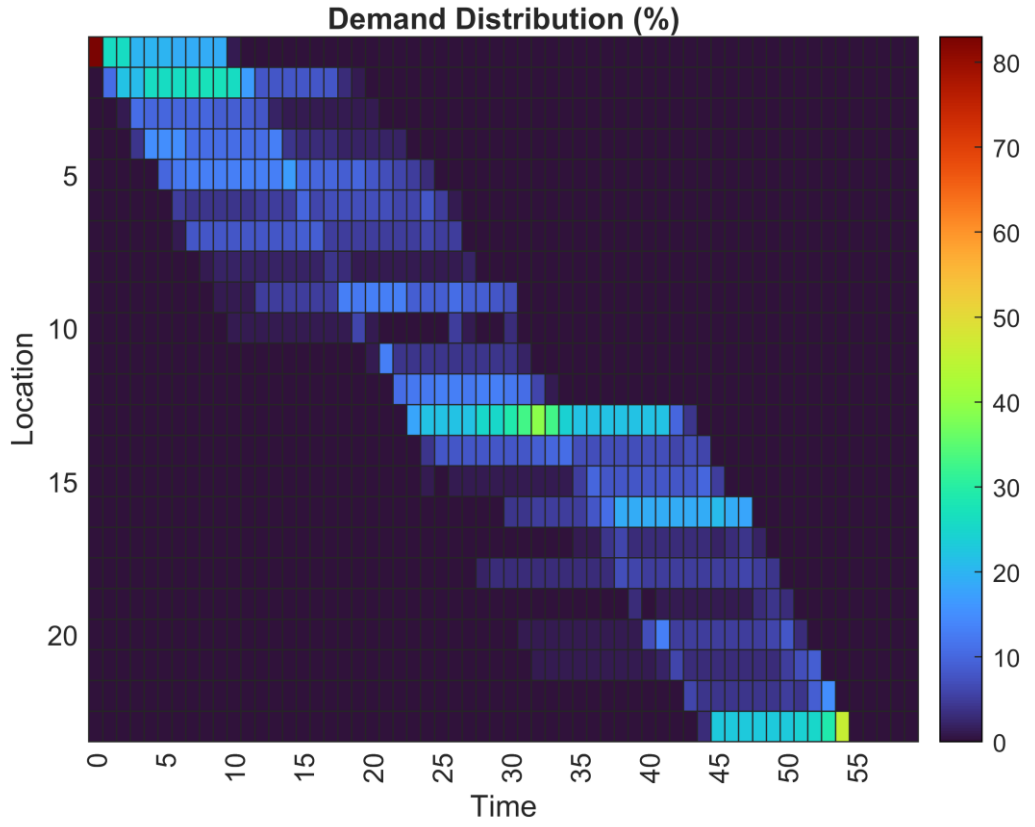


Small changes on IC of HOS
Have an impact on demand

$0 parking fees



$5 per hour fees



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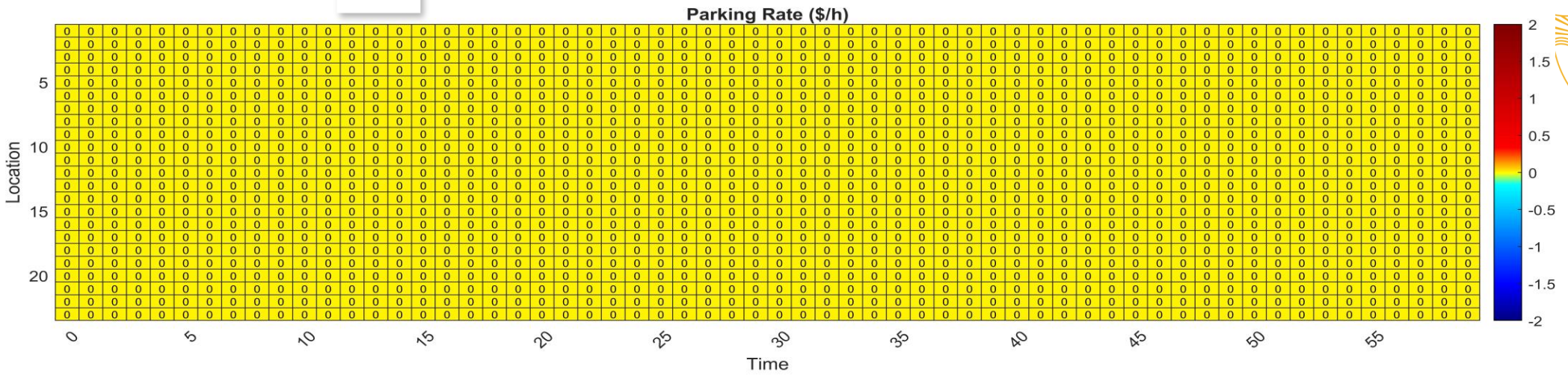

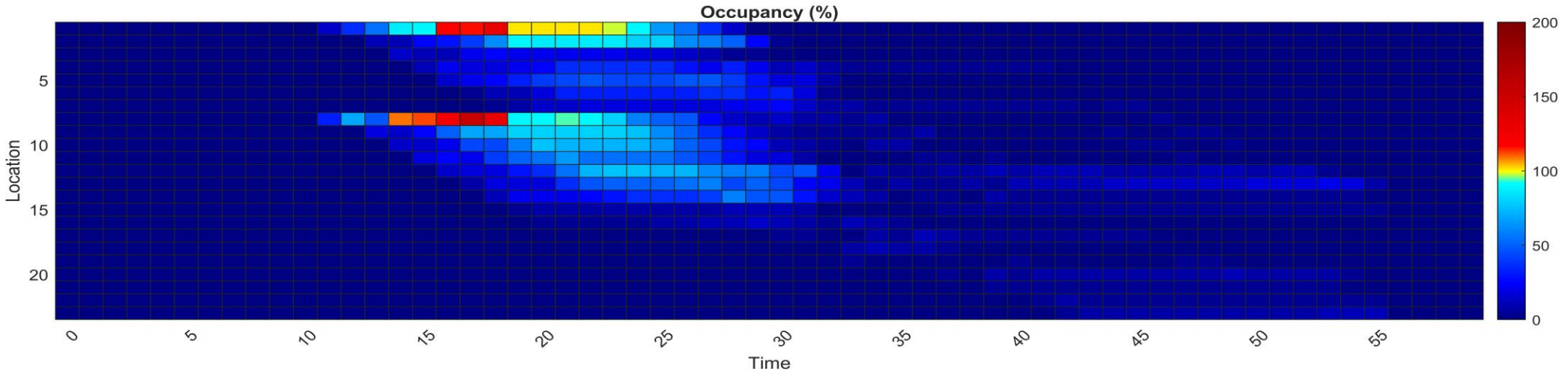

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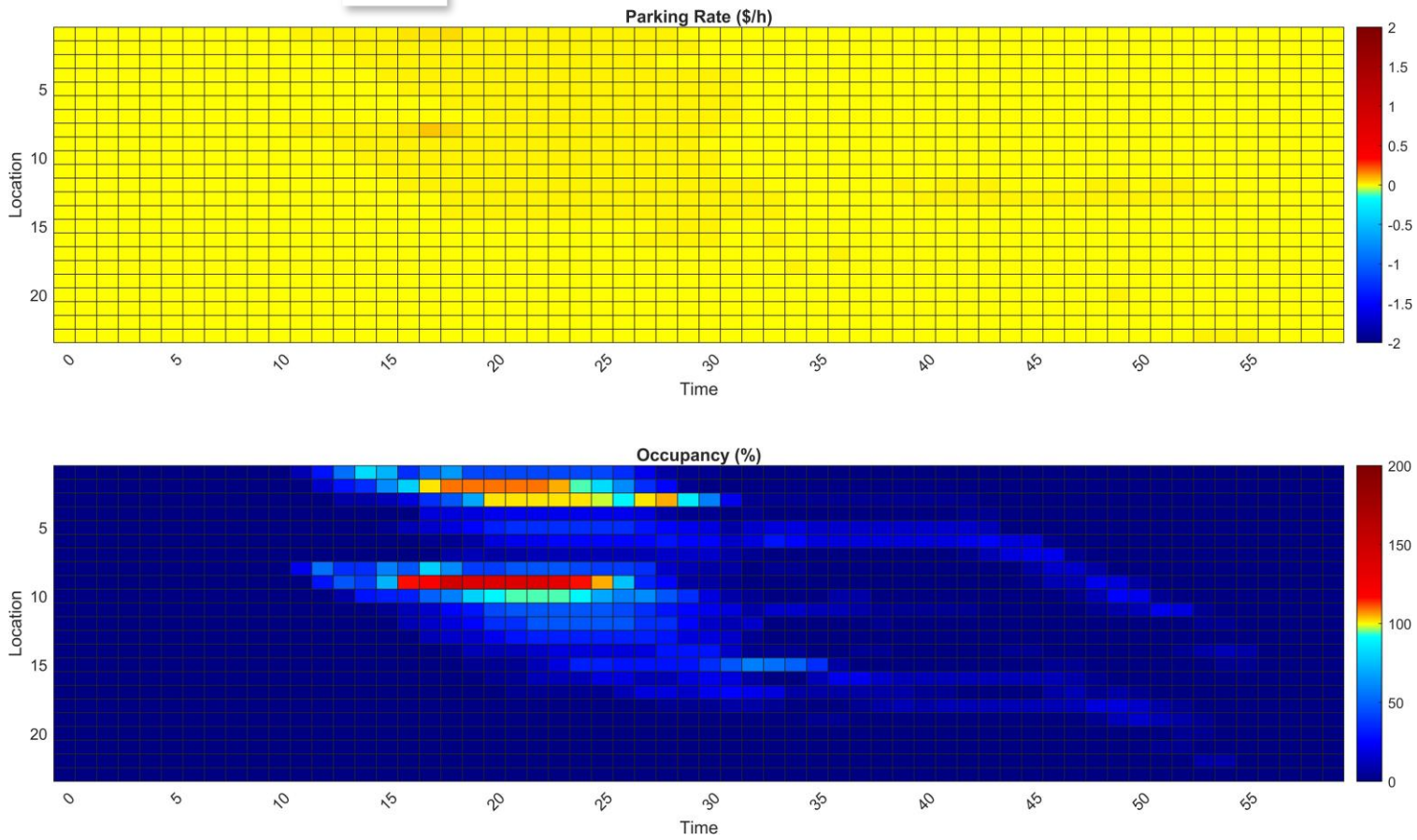

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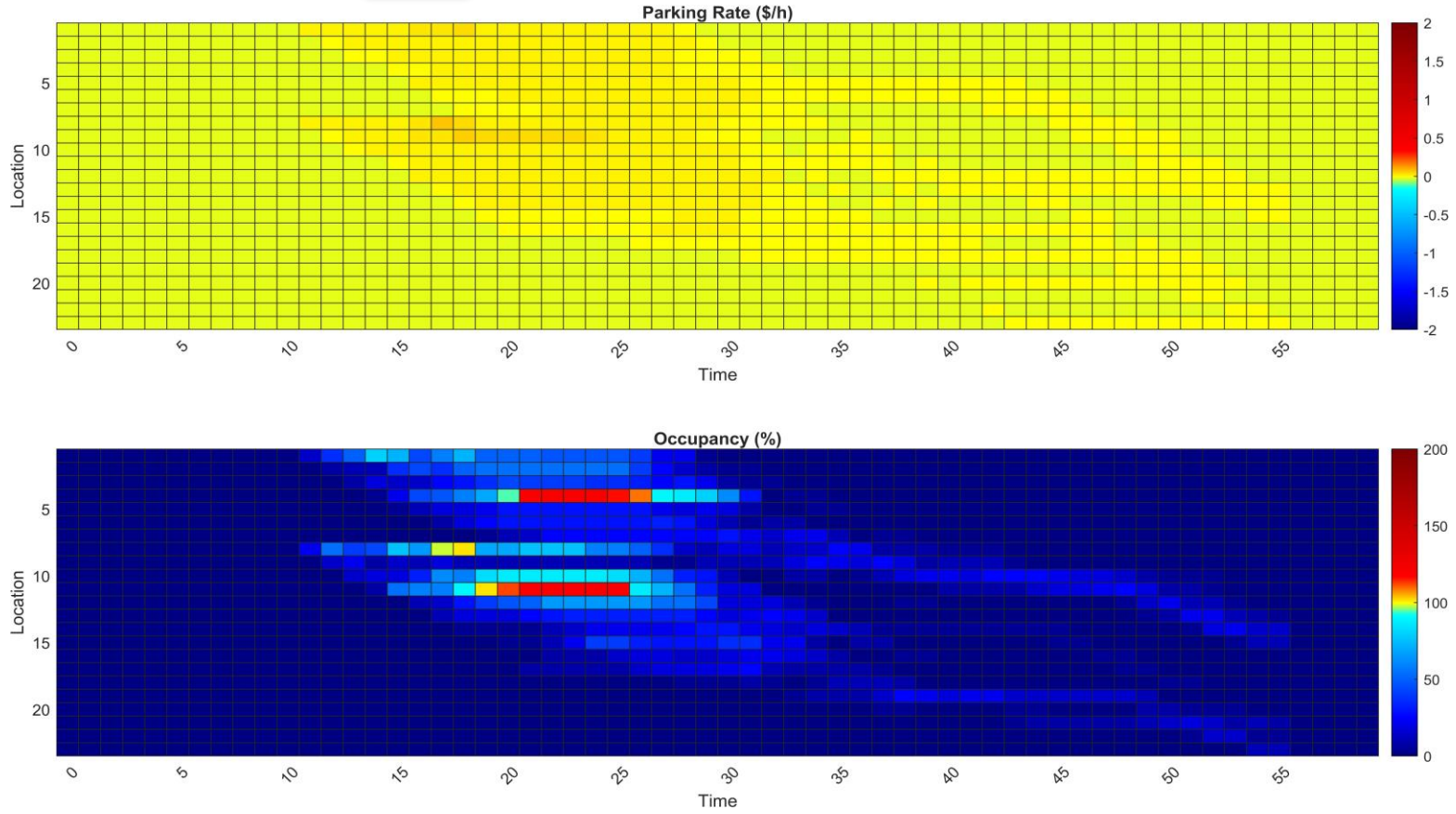

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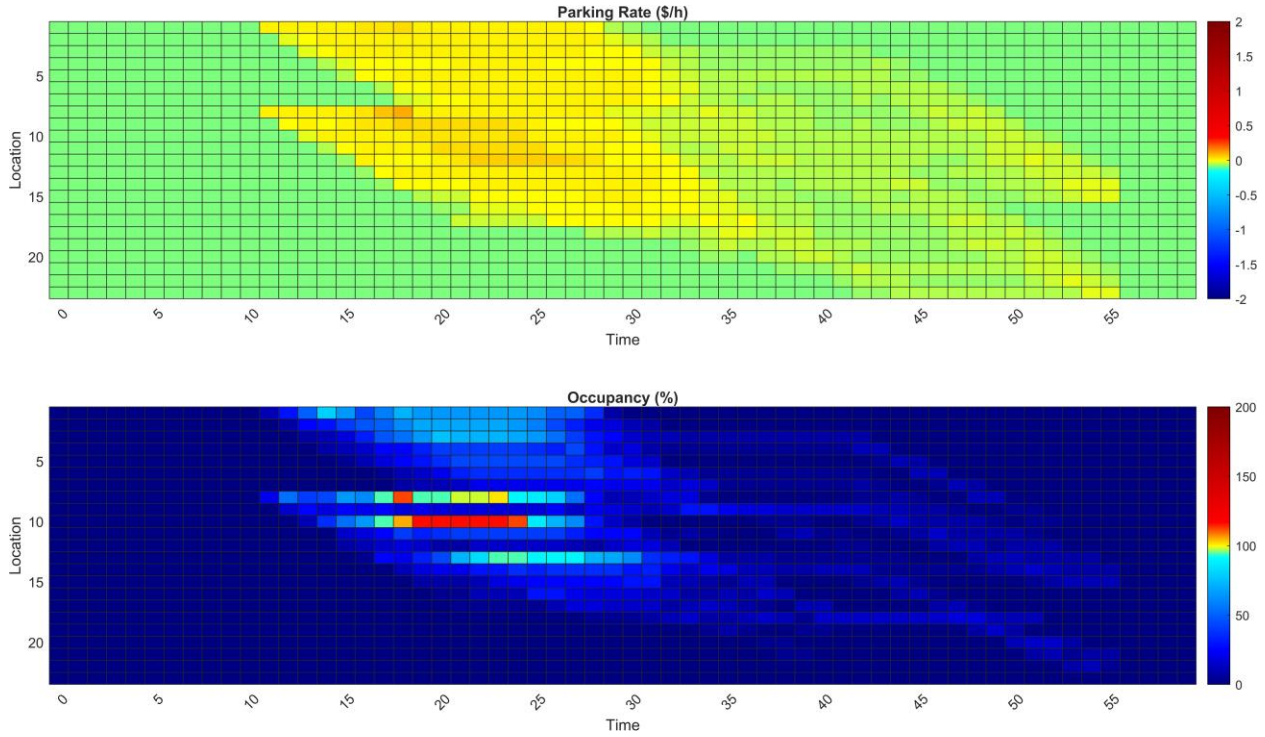

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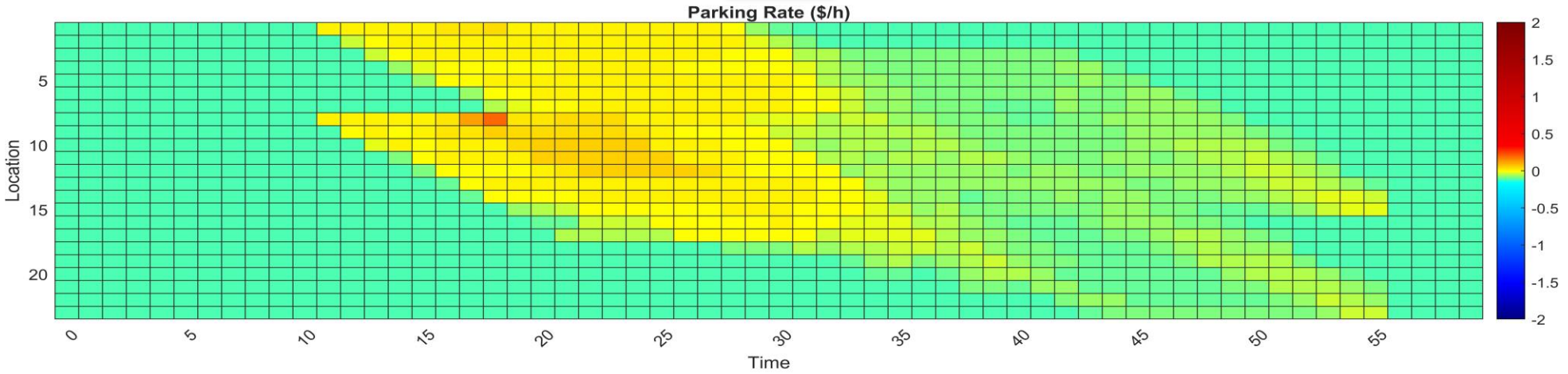
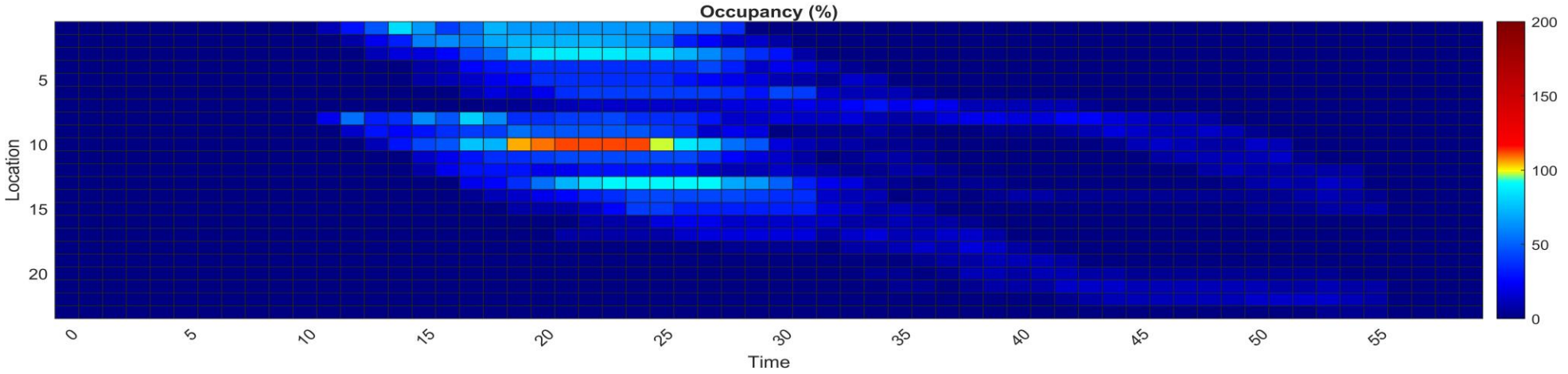
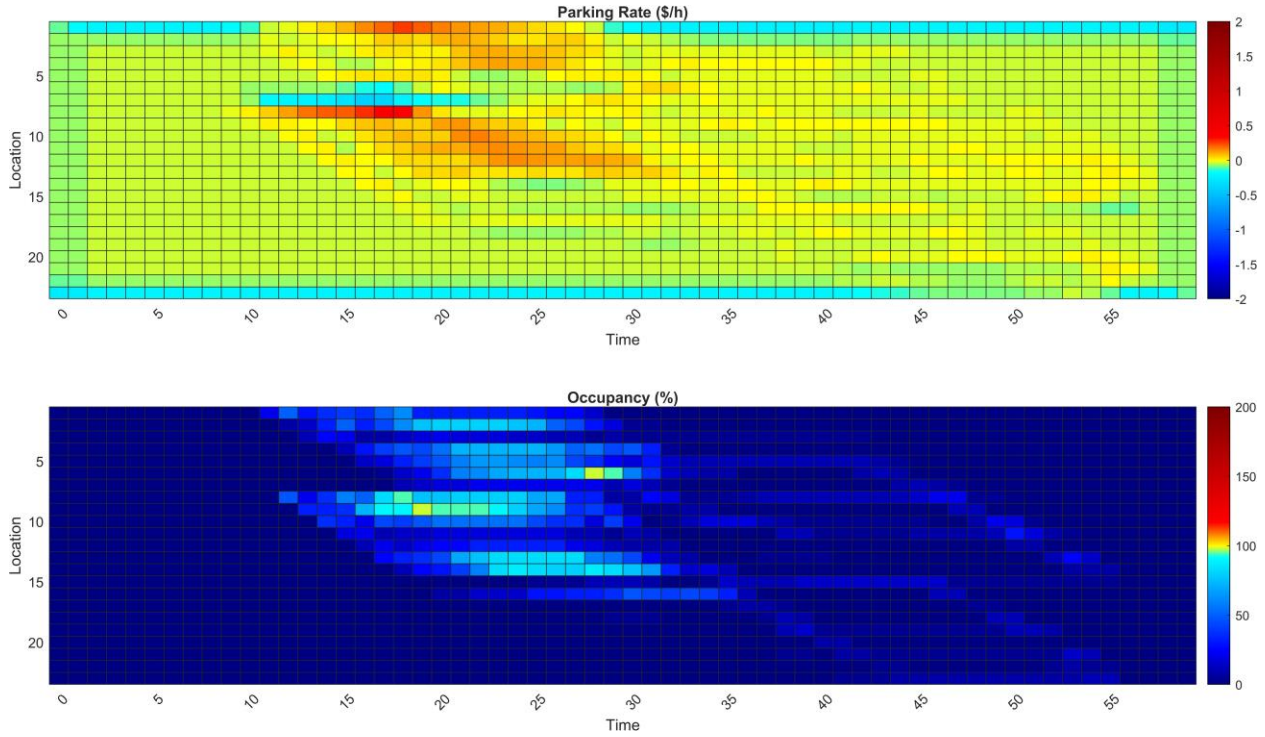

Parking Rate ($/h)
Location
5
10
15
20
0
5
10
15
20
25
30
35
40
45
50
55
Time
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2


Occupancy (%)
Location
5
10
15
20
0
5
10
15
20
25
30
35
40
45
50
55
Time
200
150
100
50
0

T= 14



CONCLUSIONS

- **Proposed a centrally coordinated pricing scheme to balance parking demand**
- **Planners make their own decisions about routing and parking and proposed them to the coordinator**
- **Coordinator identifies parking locations where demand exceeds capacity and changes prices to influence changes in time and space**
- **Process is iterative and stops when no parking locations have demand that exceeds capacity for any given time slot**
- **Central coordination allows us to look at the system as a whole and utilize hidden capacities in time and space benefiting the system and user**