Princeton University

Management of Empty
aTaxis

by

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PAVE PRINCETON AUTONOMOUS VEHICLE ENGINEERING

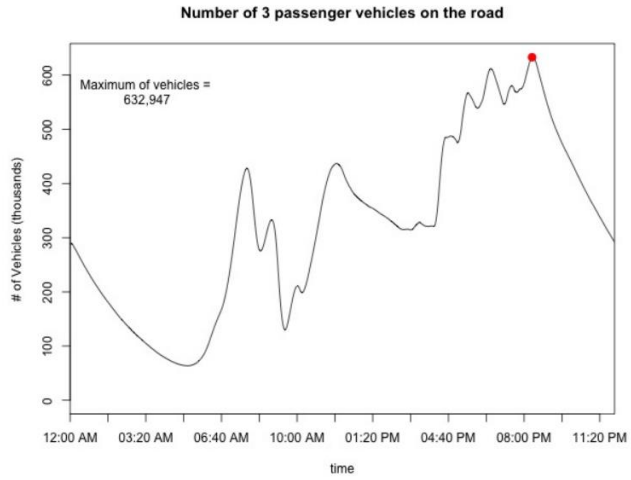
Key References

- S. Zhu'16 "Making Transportation Great Again" 2016 Senior Thesis
- S. Zhu'16 & A. Kornhauser*71 *Interplay Between Fleet-size, LoS and EmptyRepositioning*

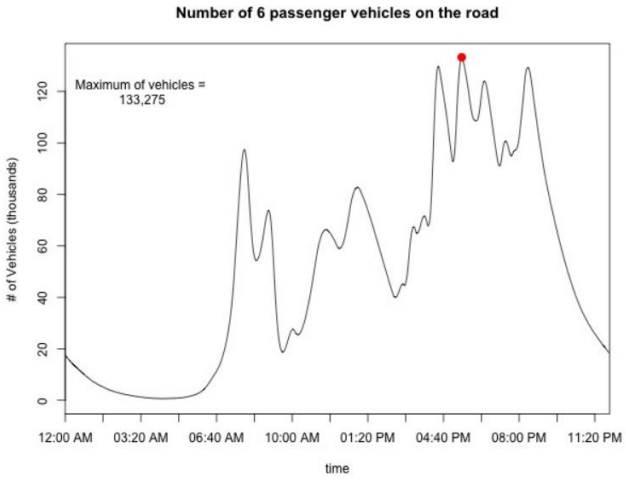
Basic Problem:

- Demand for aTaxis is NOT Symmetric (even in the long run)
- Thus empty aTaxis end up where no one else wants to get in.

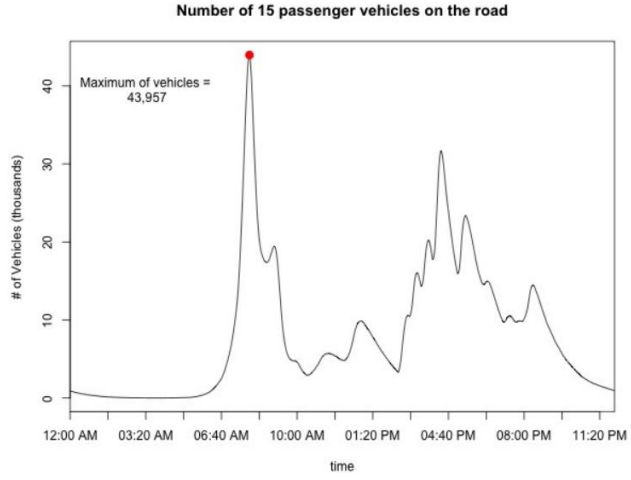
- Thus they need to be repositioned
- If you have a big enough fleet, you may be able to wait a long time, but eventually, you'll need to reposition them.



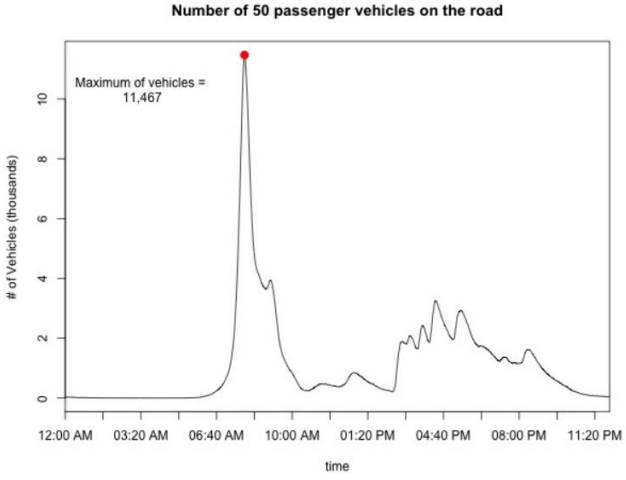
(a) 3 passenger vehicles



(b) 6 passenger vehicles



(c) 15 passenger vehicles



(d) 50 passenger vehicles

FIGURE 2 : Number of vehicles on the road as a function of time. The minimum number of vehicles needed to operate the system is the maximum of each vehicle type.

Early Morning Repositioning Costs

$$
\begin{aligned}
&\min \sum_{i \in \mathscr{I}} \sum_{j \in \mathscr{J}} D_{ij} T_{ij} \\
&\text{subject to } T \geq 0 \\
&\qquad T_{i,i} = 0 \\
&\qquad \sum_{i \in \mathscr{I}} T_{ij} = A_j, \quad \forall j \in \mathscr{J} \\
&\qquad \sum_{j \in \mathscr{J}} T_{ij} = P_i, \quad \forall i \in \mathscr{I}
\end{aligned}
\tag{1}
$$

where:

D_{ij} is the distance between aTaxi stand i and aTaxi stand j, calculated as $1.2^{*}D_{cartesian}$.

T_{ij} is trip matrix, or the number of vehicles moved from aTaxi stand i to aTaxi stand j.

$\mathscr{I}$ and $\mathscr{J}$ are the set of active aTaxi stand.

P_i is the number of excess vehicles available at the aTaxi stand i.

A_j is the number of vehicles needed at pixel j.

Near-by Repositioning

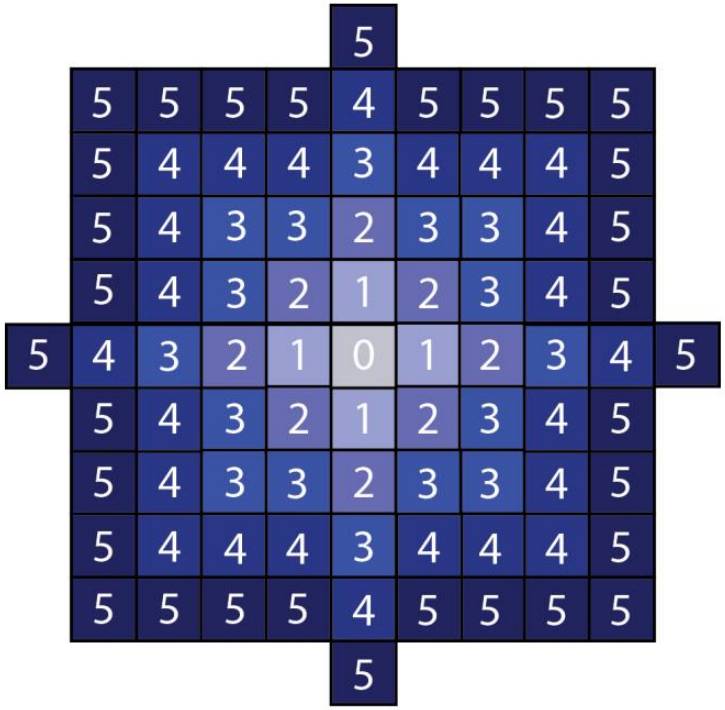


FIGURE 3 : aTaxi stands that can be reached from the departure stand within 5 minutes a
30 mph travel

Near-by Repositioning

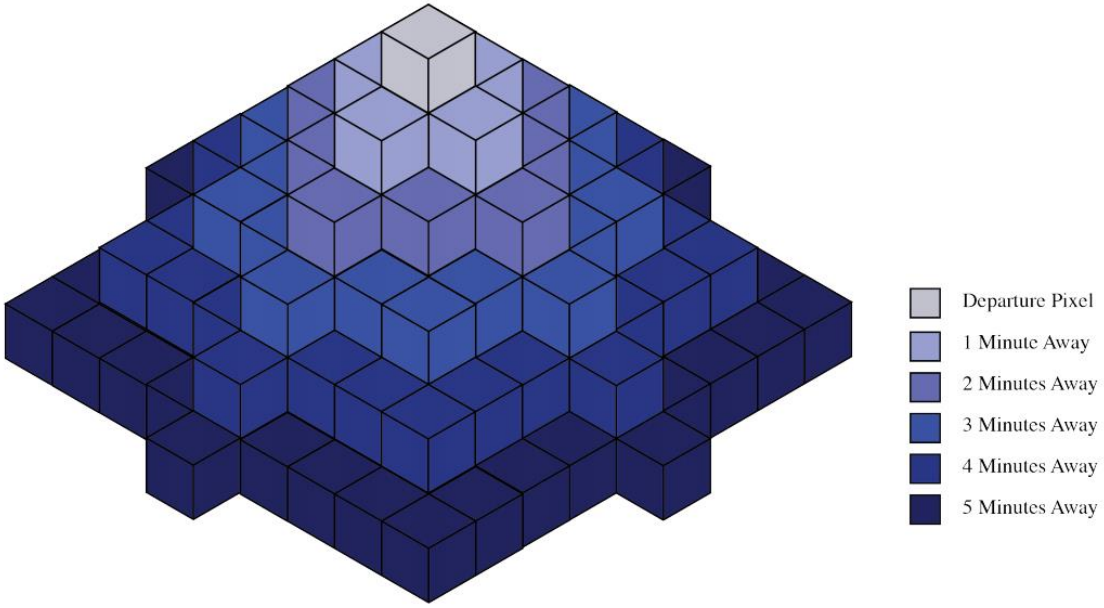


Figure 5.2: Voxelization of pixels in local repositioning

Repositioning v Fleet Size: NJ

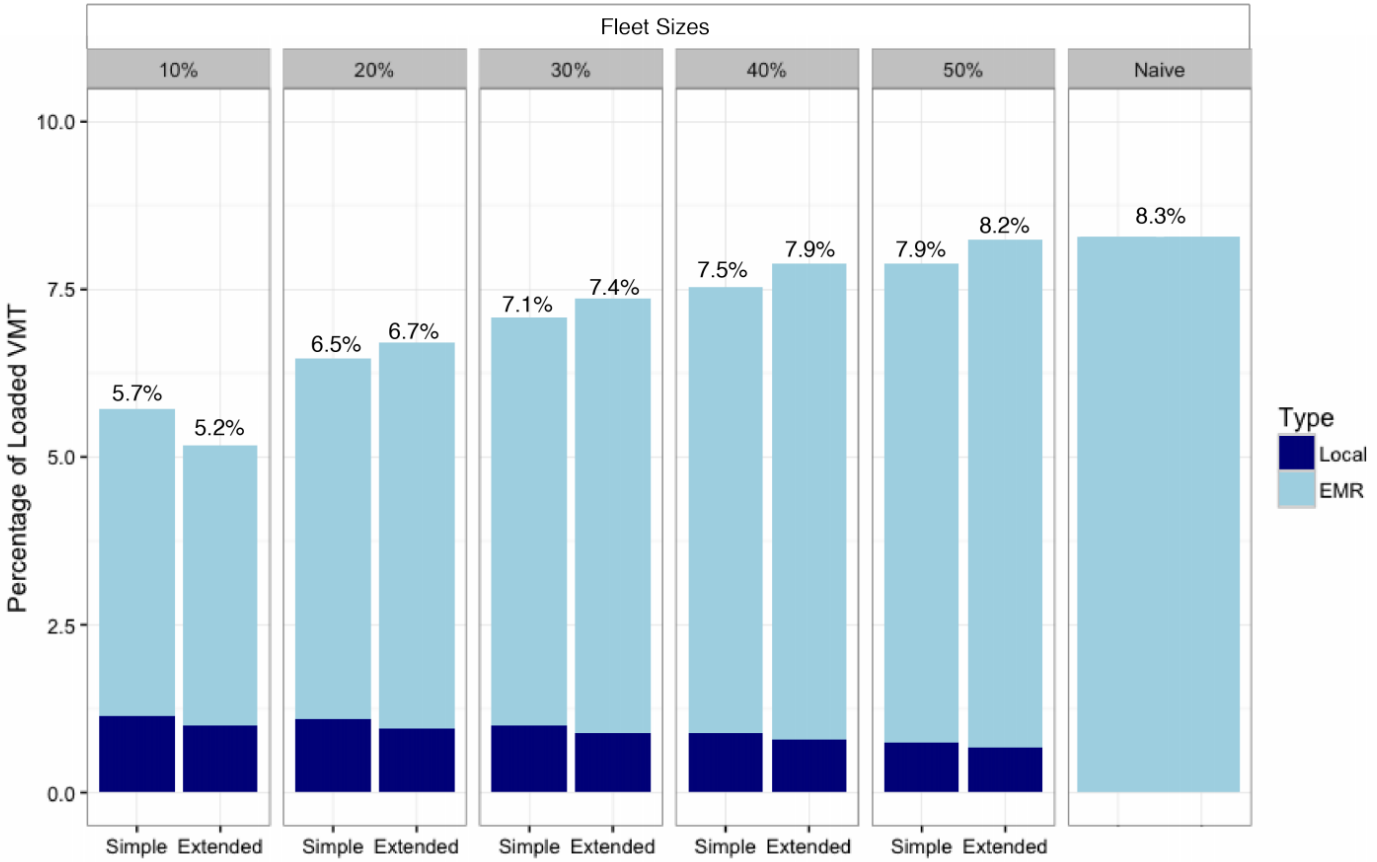
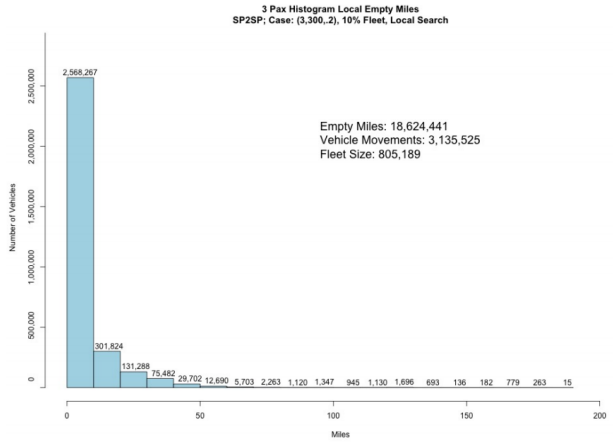
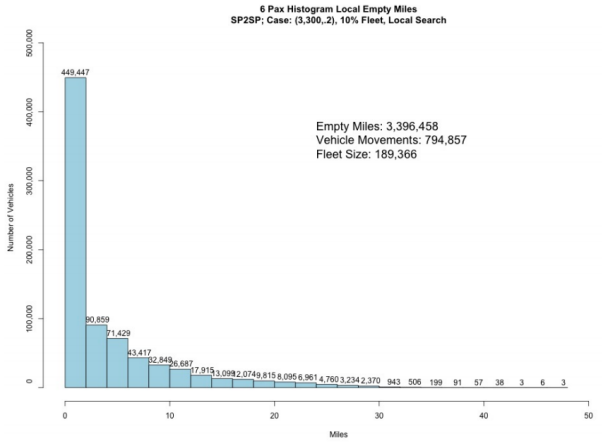


FIGURE 4 : Comparison of empty vehicle repositioning cost, as a percentage of loaded vehicle miles traveled, for fleets of varying sizes

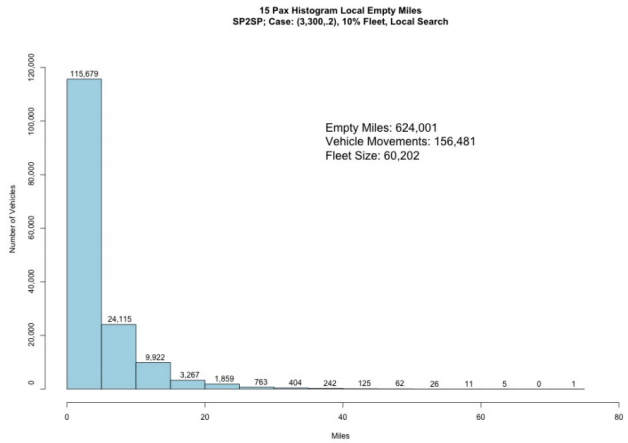
Empty Miles: NJ



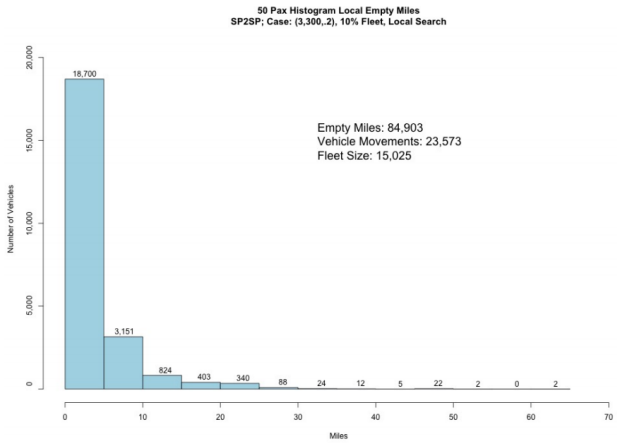
(a) 3 passenger vehicles



(b) 6 passenger vehicles



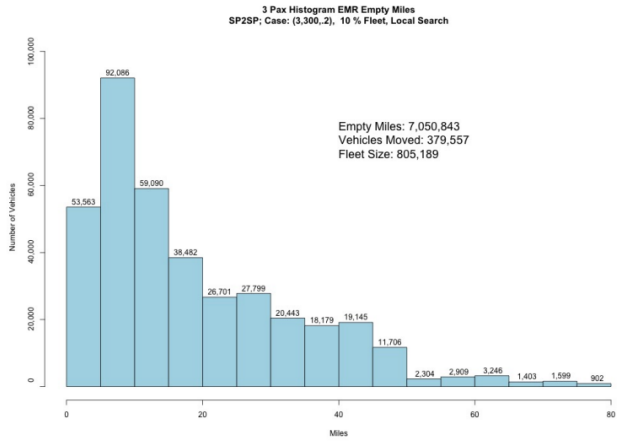
(c) 15 passenger vehicles



(d) 50 passenger vehicles

FIGURE 5 : Histograms of empty distances traveled by vehicle type for the 10% fleet size case in local repositioning.

Empty Miles: 10% Fleet Size case



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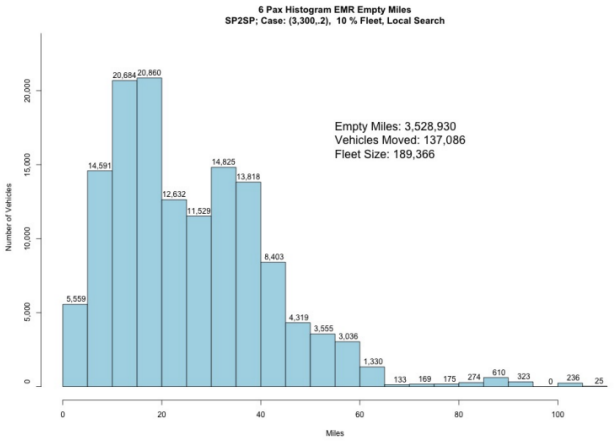

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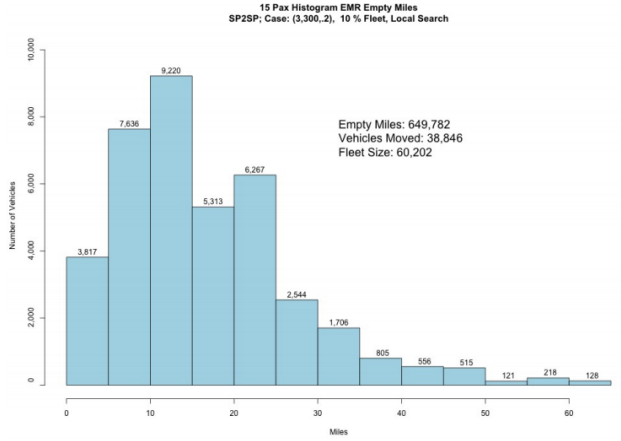

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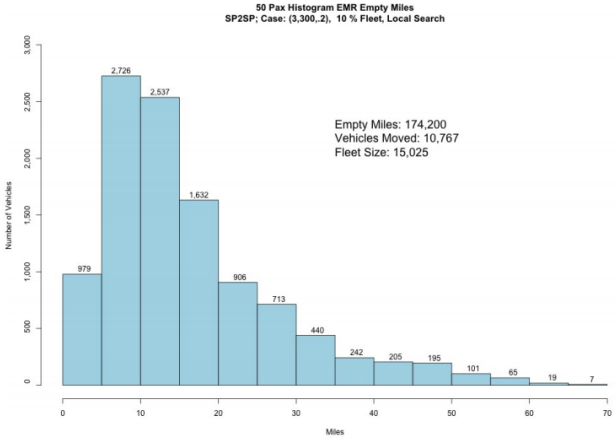

(d) 50 passenger vehicles

FIGURE 6 : Histograms of empty distances traveled by vehicle type for the 10% fleet size case in Early Morning Repositioning.

Summary

TABLE 3 : Percentage of vehicle trips served within advertised level of service in each repositioning strategy

	Fleet Size					
	10%	20%	30%	40%	50%	Naive
Simple Strategy	82.7	87.7	91.3	94.1	96.1	100
Extended Search	86.7	89.6	92.0	94.1	95.9	100

TABLE 4 : Percentage of passengers served as wait time increases beyond advertised level of service for various fleet sizes

	Fleet Size				
	10%	20%	30%	40%	50%
Within advertised	95.4	96.4	97.2	97.9	98.6
Within advertised + 1 minute	95.7	96.3	97.5	98.2	98.8
Within advertised + 5 minutes	96.8	97.8	98.5	99.0	99.5
Within advertised + 10 minutes	97.8	98.7	99.2	99.6	99.8

Discussion!

Thank You

alaink@princeton.edu

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