הסיבה העיקרית לזמני חיפוש חניה ארוכים

יום עיון לתלמידי מחקר
בתחומי העיר והעירוניות
22 לינואר, 2018,
תל אביב,
ישראל

ניר פולמן, יצחק בננסון

המעבדה לגיאוסימולציה,
החוג לגיאוגרפיה וסביבת האדם,
אוניברסיטת תל אביב,
ישראל

Parking search in a city center is always frustrating…
all parking spots are occupied all the time…

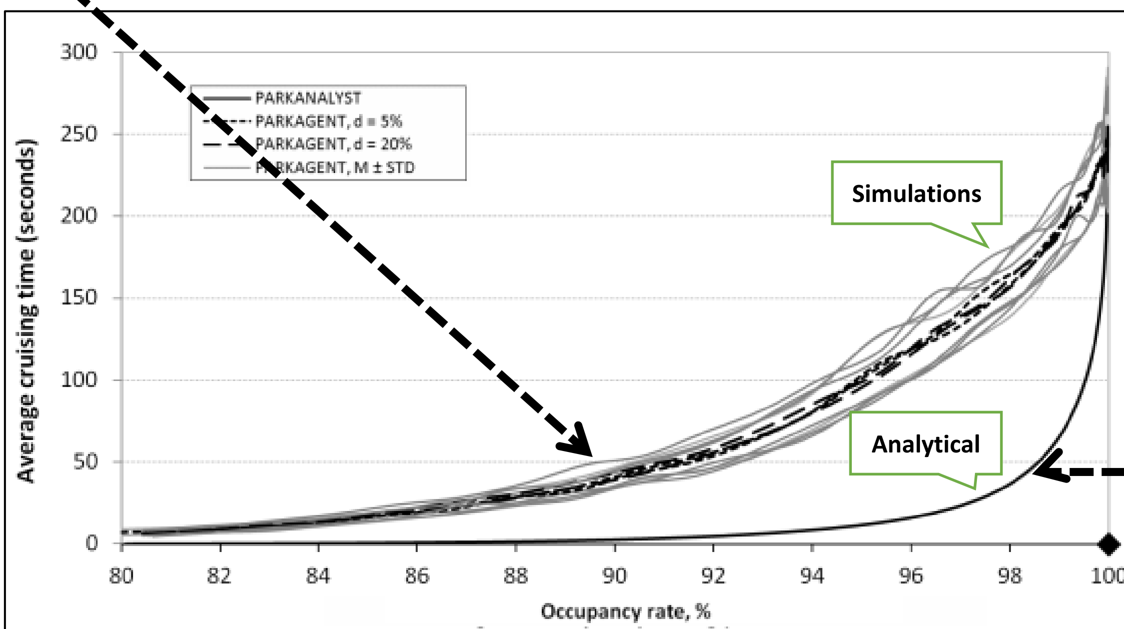
But how exactly do occupancy and cruising time relate?

Simulations

Short cruising time until the occupancy reaches **~90%** (1 free spot of 10)

Analytical models

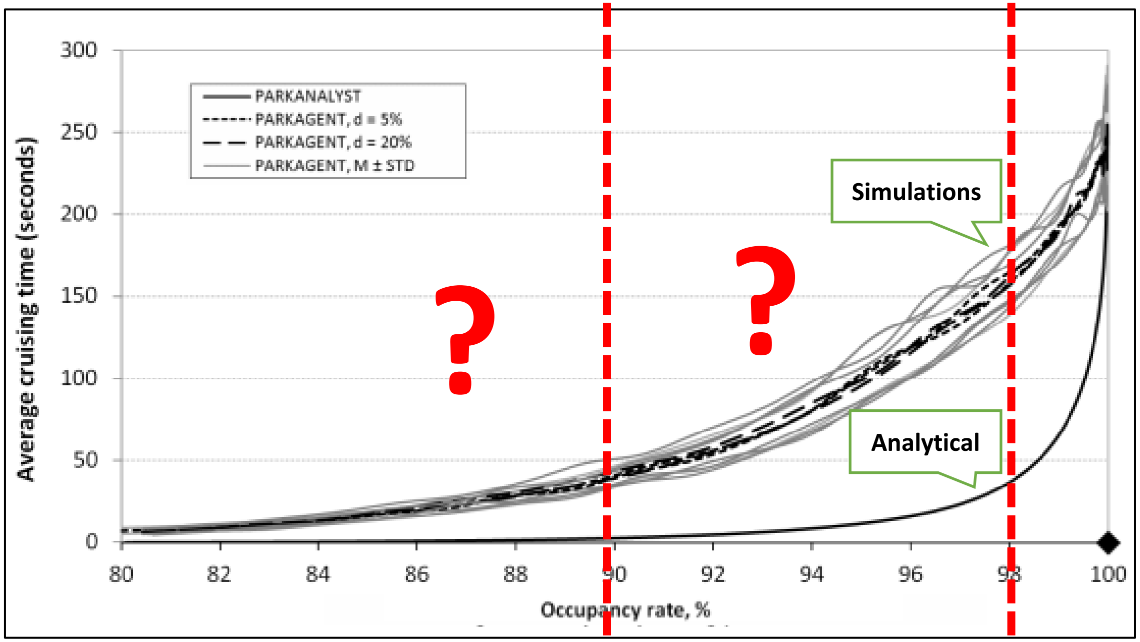
Short cruising time until the occupancy reaches **~98%** (1 free spot of 50)

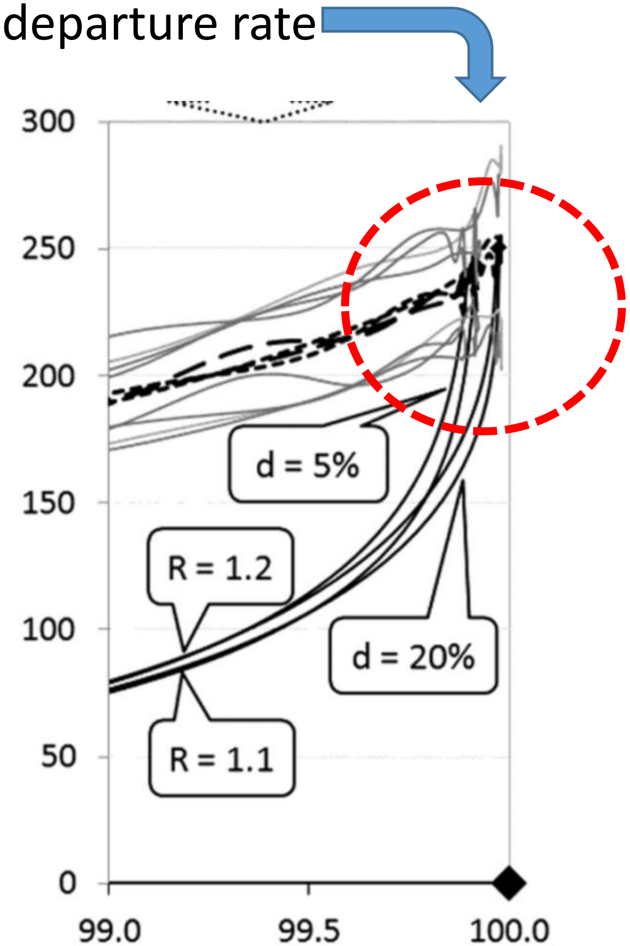


Nadav Levy, Karel Martens & Itzhak Benenson (2013) Exploring cruising using agent-based and analytical models of parking, Transportmetrica A: Transport Science, 9:9, 773-797

If D/S > 1 everywhere, cruising time depends only on departure rate

But how can we explain relatively long parking search time for D/S between 0.90 – 0.99?
As well as non-zero search time for D/S < 0.9?



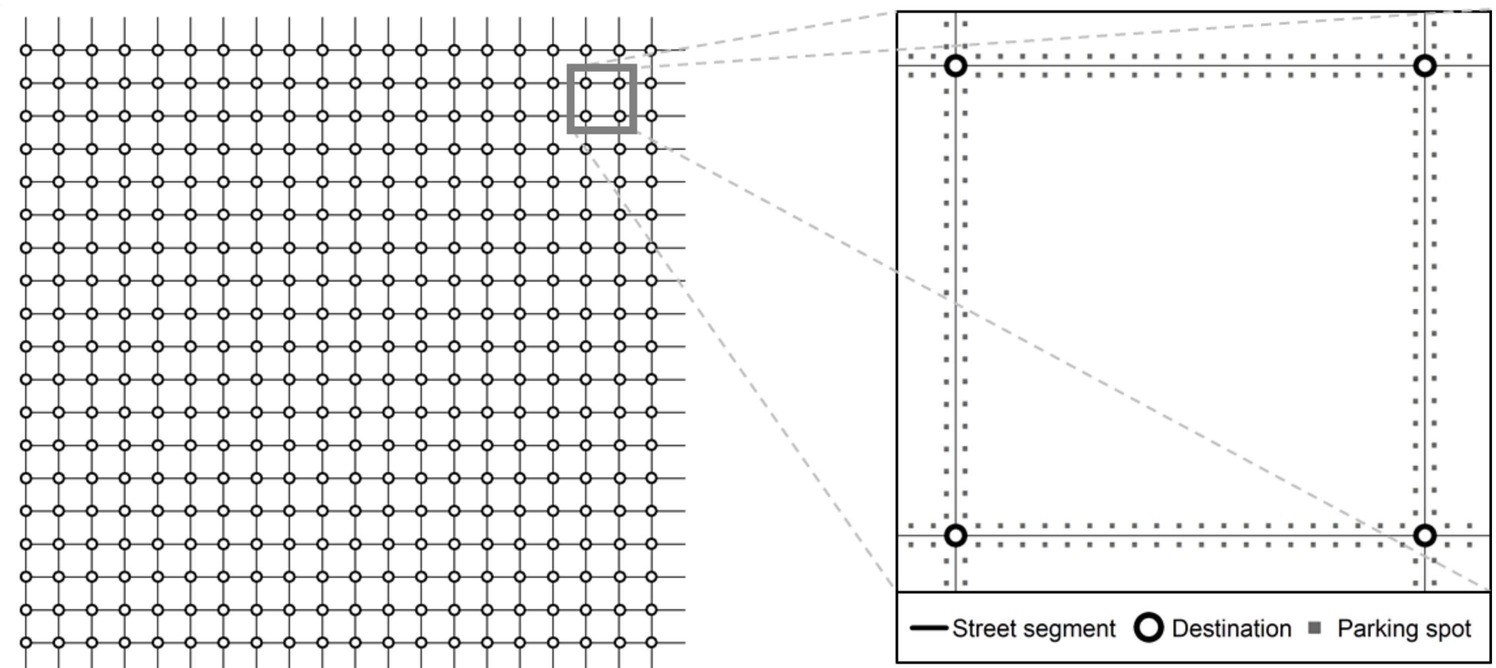


Levy et al 2013 simulation:

- *Spatially uniform demand and supply, drivers assigned a random destination*
- Due to stochastic effects, occupation varies in space, some drivers are bound to fail
- In reality, demand/supply is never uniform
- **Would cruising times change with heterogeneity of demand/supply?**

PARKGRID dynamic parking ABM

- 20 x 20 Two-way, 100 m links, 20 parking spots on each side.
- “destination buildings” at junctions
- 1:80 buildings to parking spots ratio.



Driver agents

- Enter the system at assigned destination i and start cruising
- Drivers aiming at destination i are generated as Poisson process, per hour rate λ_i
- Parking duration: uniformly distributed on $[P_{min}, P_{max}]$

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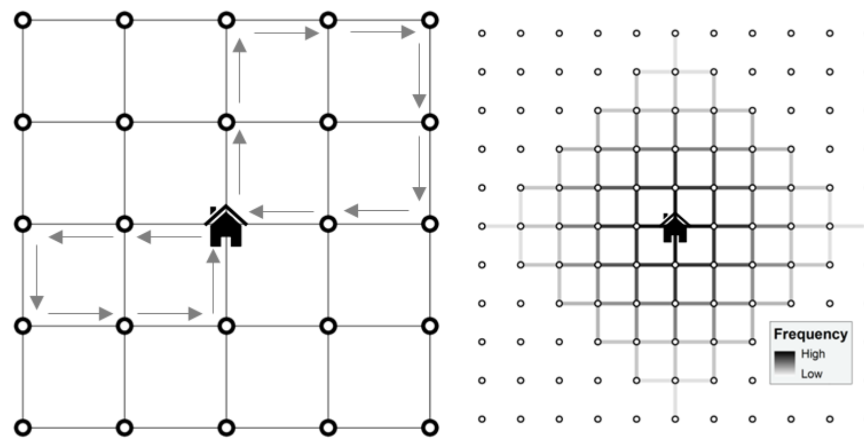
Search behavior of driver agents

- Constant cruising speed: 12 km/h = 30 seconds/link (time unit)
- Maximum allowed cruising time M = 20 minutes in all scenarios
- Search tactics: Biased random walk (Fulman et al., in press)

Random walk biased toward the destination



Decision at previous junction	Random walk search tactic: Decision probabilities depending on distance between junction and destination and the decision made at a previous junction									
	$d < 100$,		$100 \leq d < 200$		$200 \leq d < 300$		$d \leq 300 < 400$		$d \geq 400$	
	Closer	Furth	Closer	Furth	Closer	Furth	Closer	Furth	Closer	Furth
Closer	Irr	1	0.65	0.35	0.85	0.15	0.9	0.1	Irr	
Further	Irrelevant		Irr	1	0.8	0.2	0.85	0.15	1	0

Basic scenario with **homogeneous** and **heterogeneous** demand/supply

- Overall demand to supply ratio = q < 1
- Let overall q = 0.85 (after Shoup, 2005) average destination demand D = 0.85 * 80 = 68
- Simulation time: 9:00 – 16:00

Employees

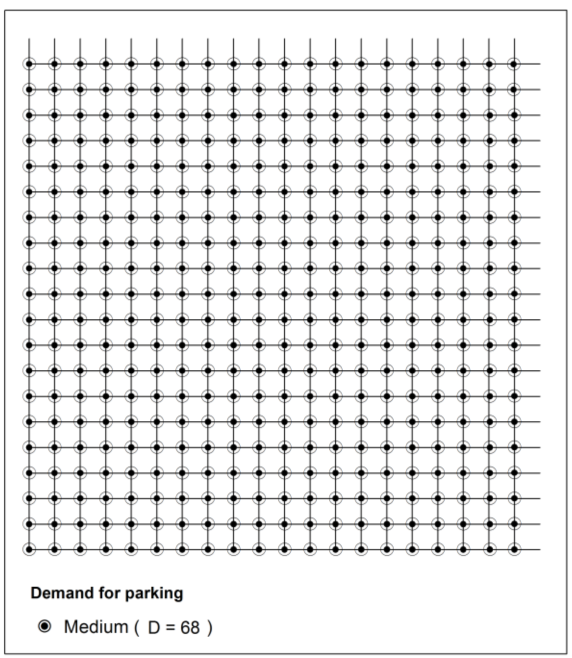
- Arrive between 9:00 – 10:00
- Destination arrival rate $\lambda_i = 0.8 * D$ / hour
- $P_{min} > 7$, never depart

Visitors

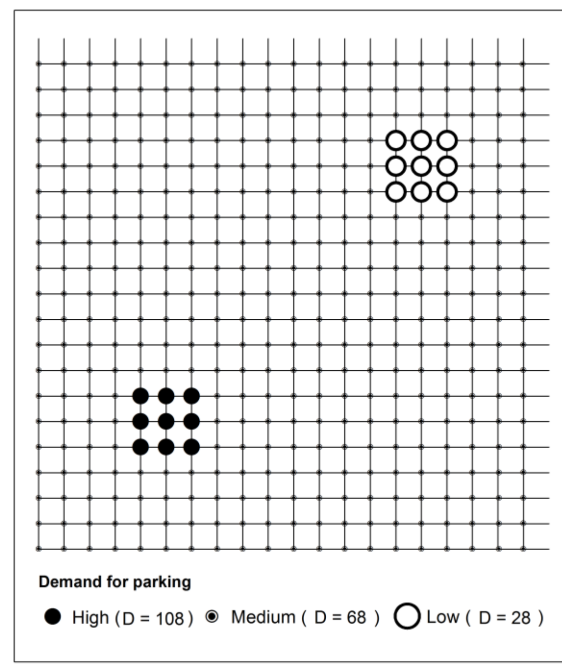
- Arrive between 9:00 – 16:00
- Destination arrival rate $\lambda_i = 0.15 * D$ / hour
- $P_{min} = 1$, $P_{max} = 2$

- **Toward 11:00 average link occupancy = 0.85, steady state is investigated**

Homogenous case

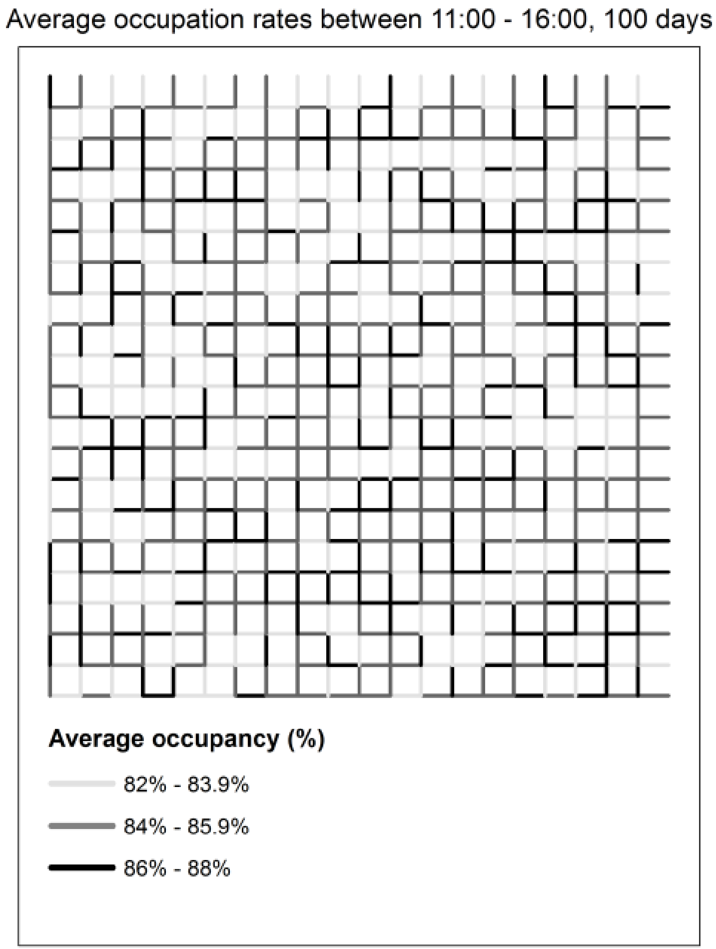


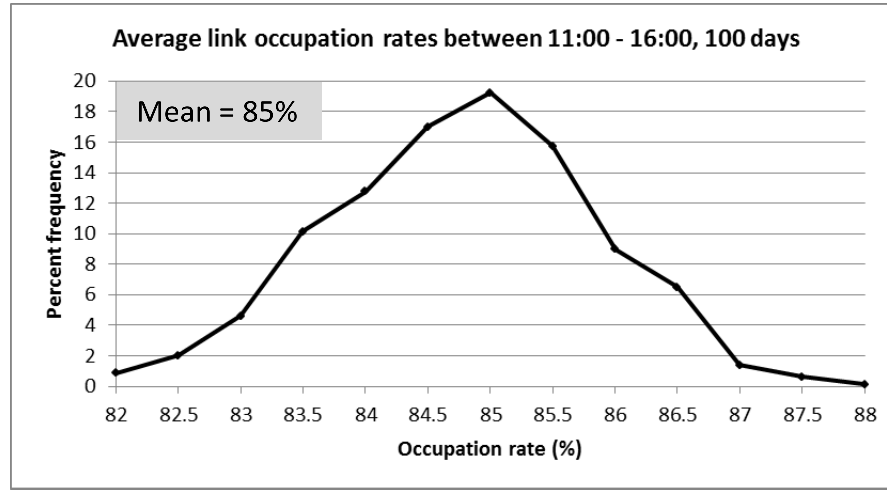
Heterogeneous case

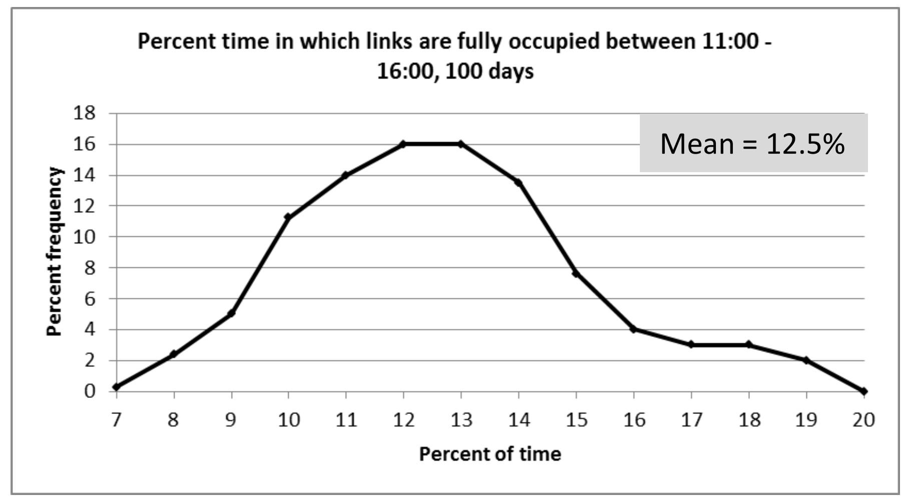


Patterns of parking occupation – **Homogeneous case**

High parking availability, links not often fully occupied

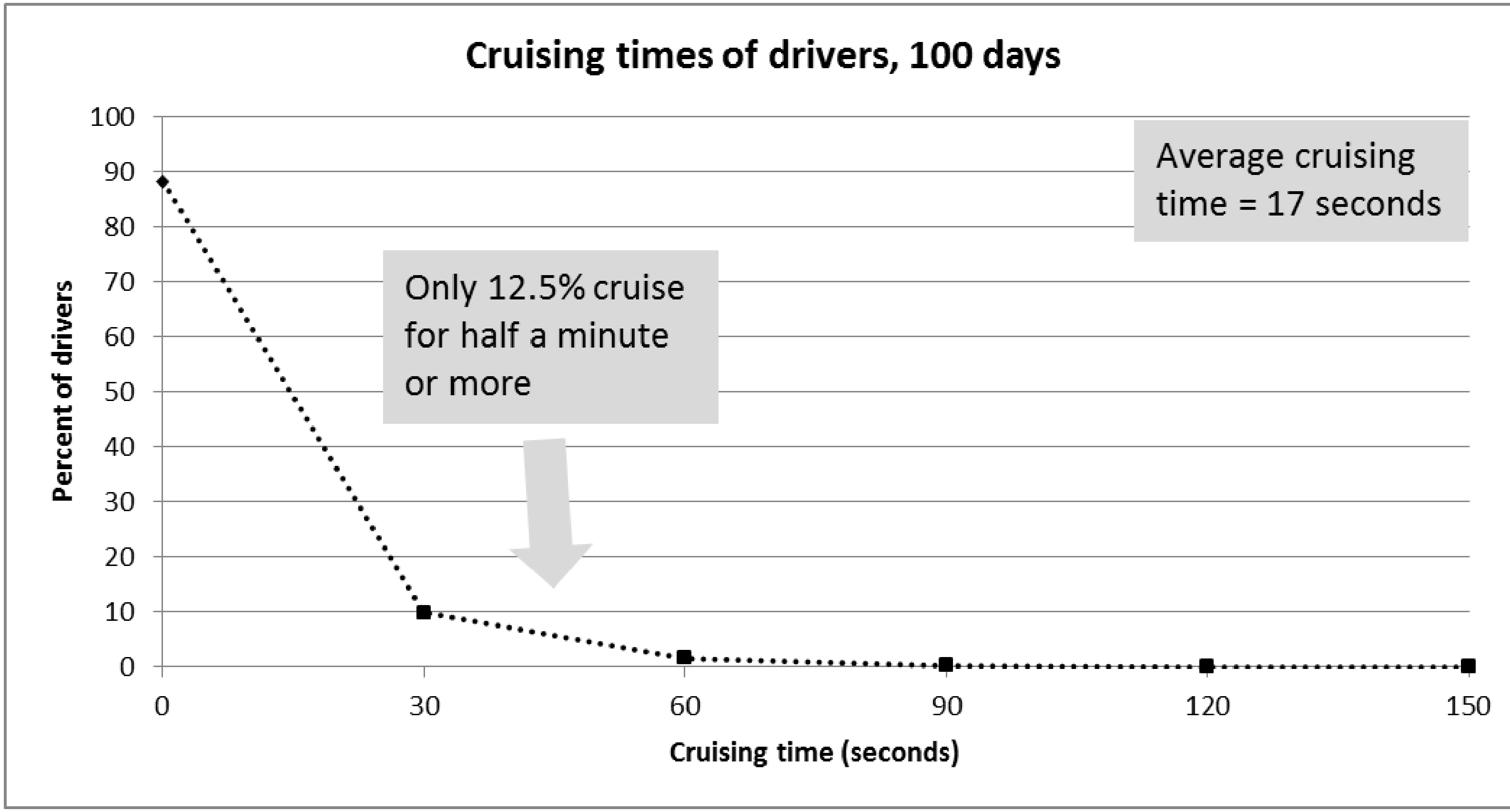






Drivers' cruising time – **Homogeneous case**

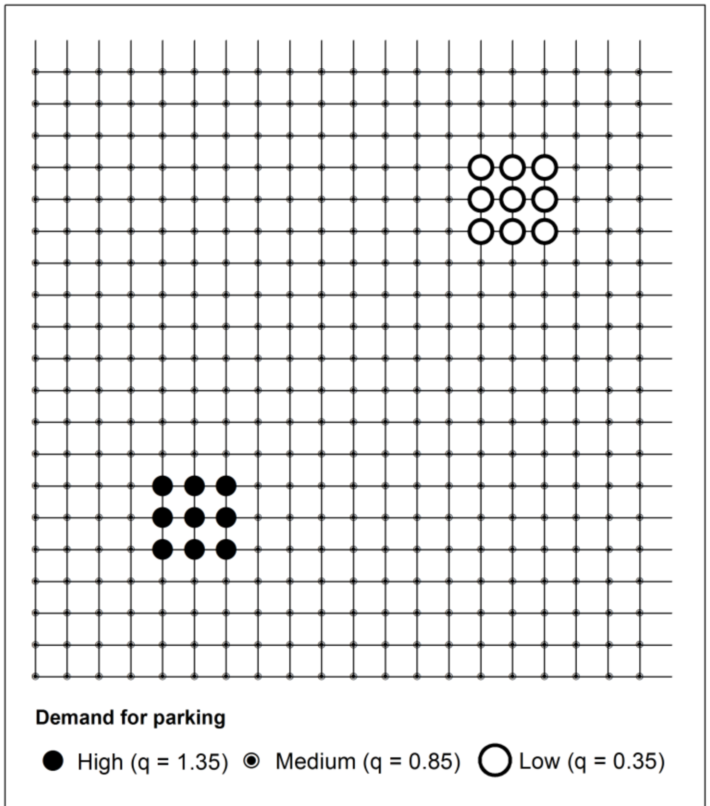
High parking availability → Short cruising times



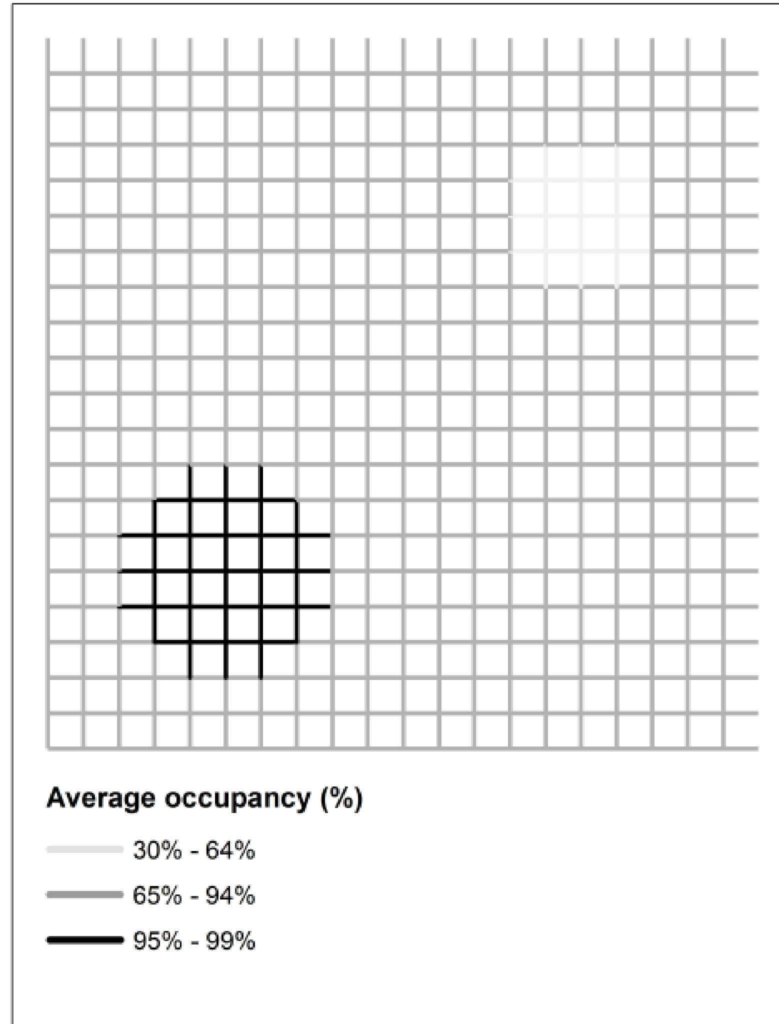
Patterns of parking occupation – **Heterogeneous case**

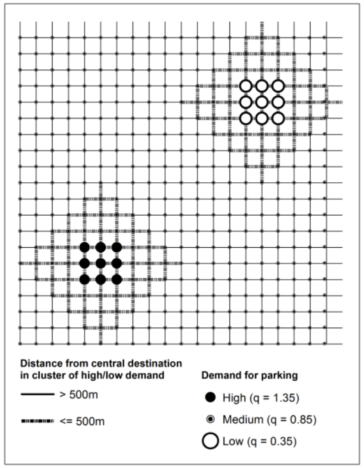
*Average occupation unchanged (85%) but Occupation rates **extremely** high in area of high demand*

Heterogeneous case



Average occupation rates between 11:00 - 16:00, 100 days



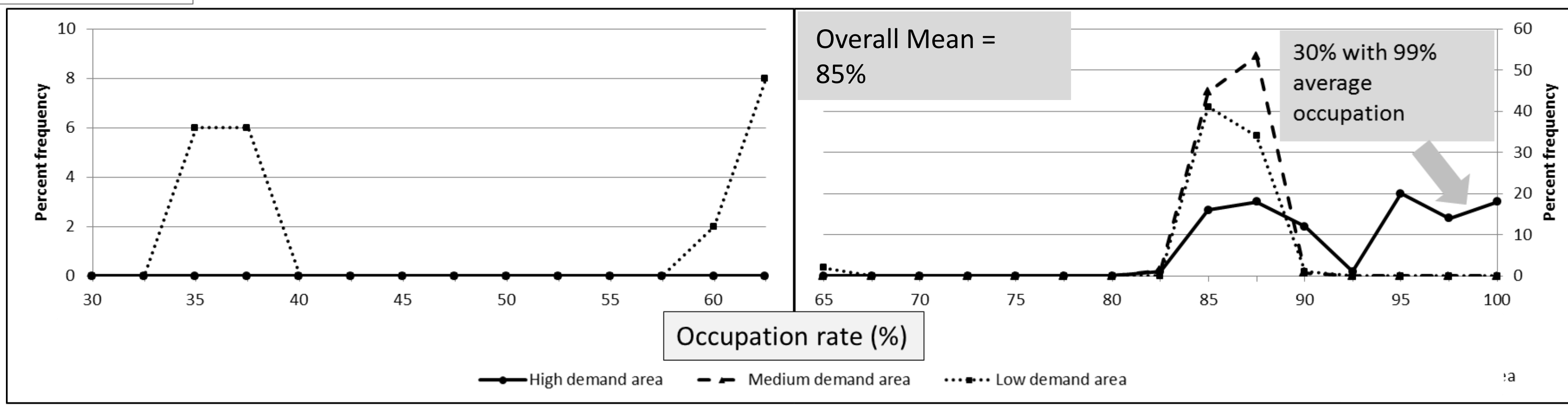


Patterns of parking occupation – **Heterogeneous case**

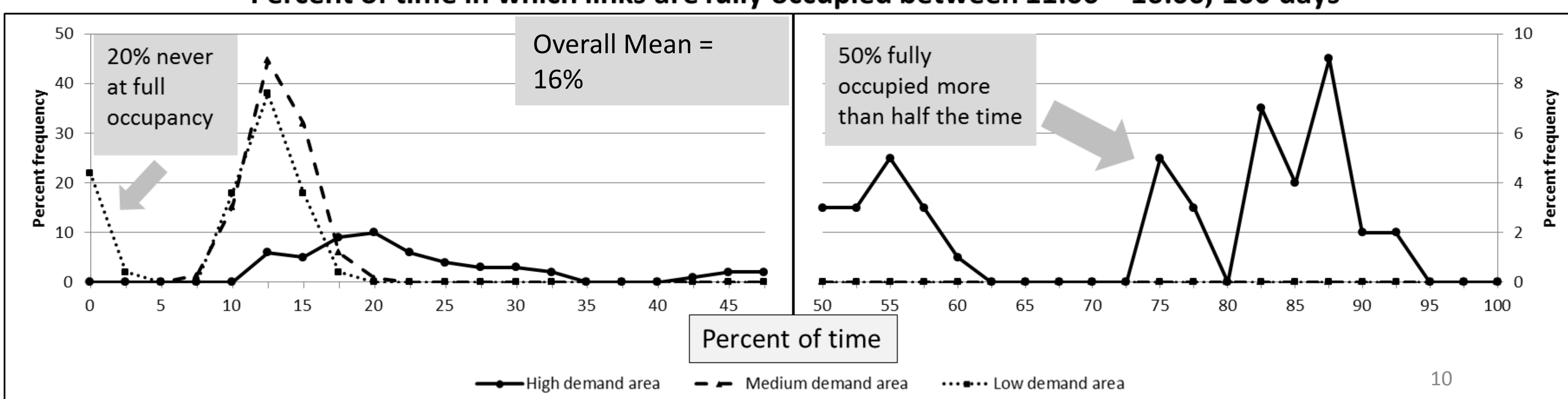
Average duration of full occupancy increases!

Parking unavailable for substantial durations of time in the area of high demand

Average link occupation rates between 11:00 – 16:00, 100 days



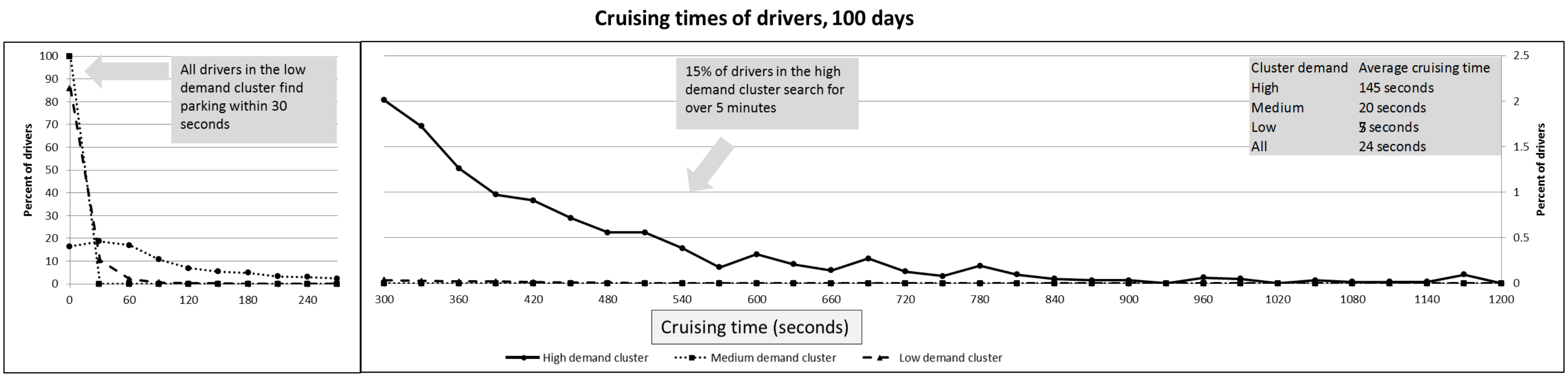
Percent of time in which links are fully occupied between 11:00 – 16:00, 100 days



Drivers' cruising time – **Heterogeneous case**

- *Cruising times vary greatly across the city*
- *Average cruising in area of high demand ~ 2.5 minutes*

That is, ***6 times the city average***



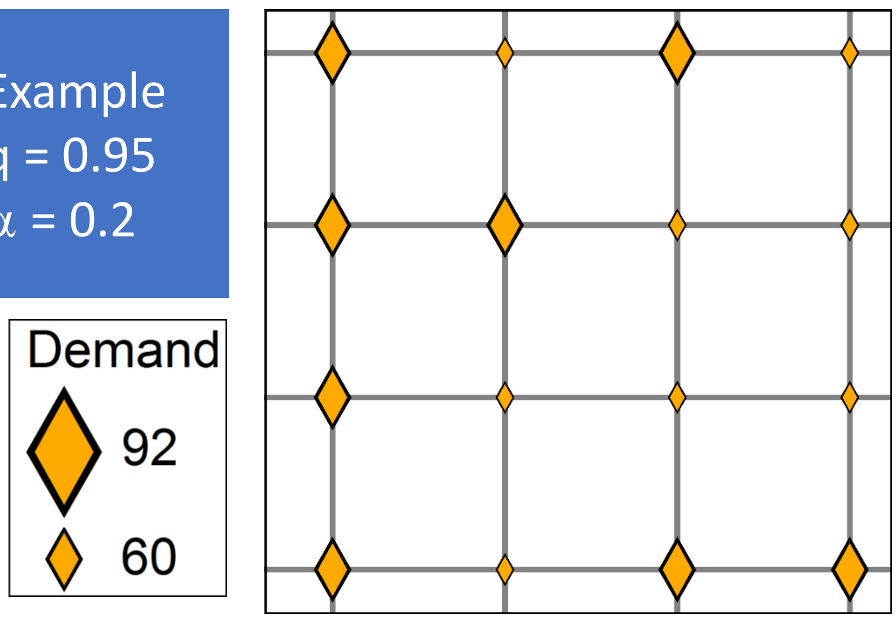
- *heterogeneous demand results in areas where parking is unavailable and parking search is long*
- ***Does this mean average occupation does not indicate cruising time?***

Cruising times with homogeneous and Heterogeneous d/s – general cases

Representation of the non-uniform parking demand

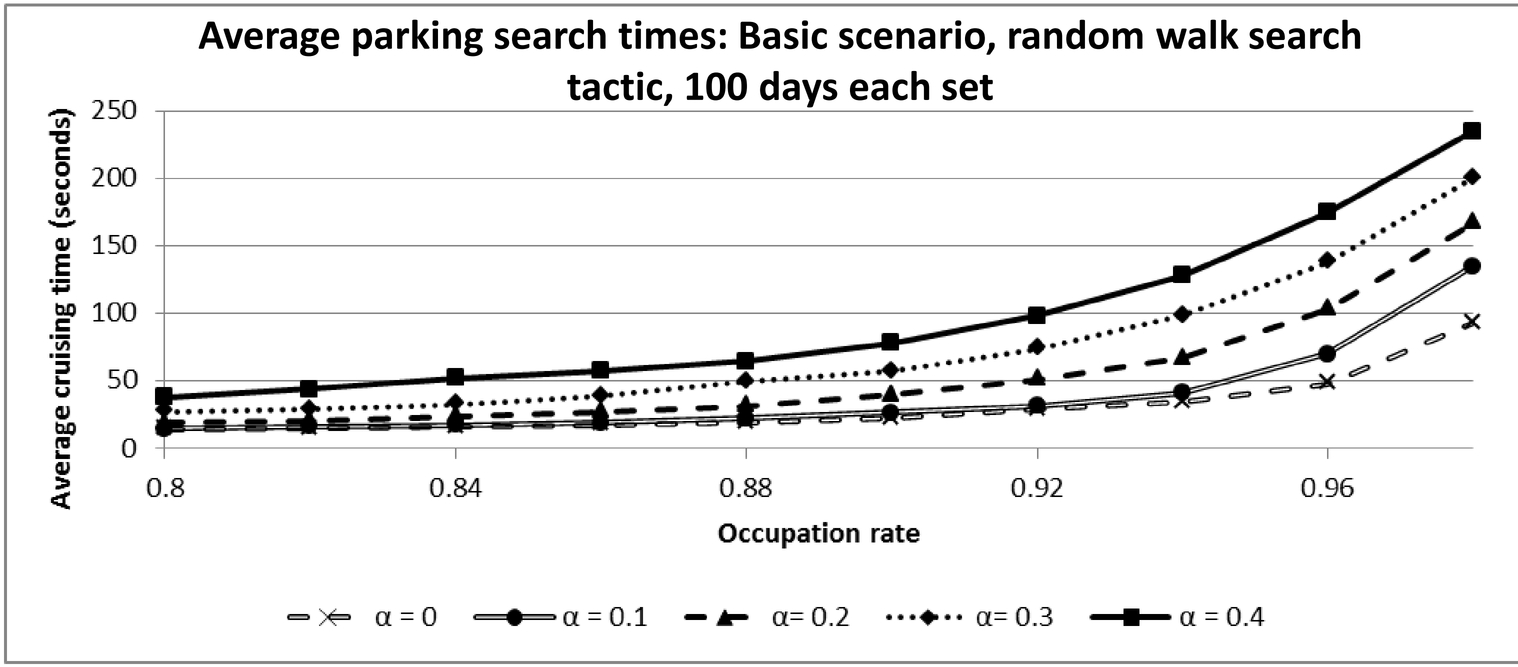
- Overall demand to supply ratio $q < 1$
- For 50% of buildings, randomly chosen, $D = (q + \alpha)*80$
- For the rest, $D = (q - \alpha)*80$, $q > \alpha$
- Rest of parameters as in the basic scenario

Example
$q = 0.95$
$\alpha = 0.2$



Cruising times with homogeneous and Heterogeneous d/s – general cases

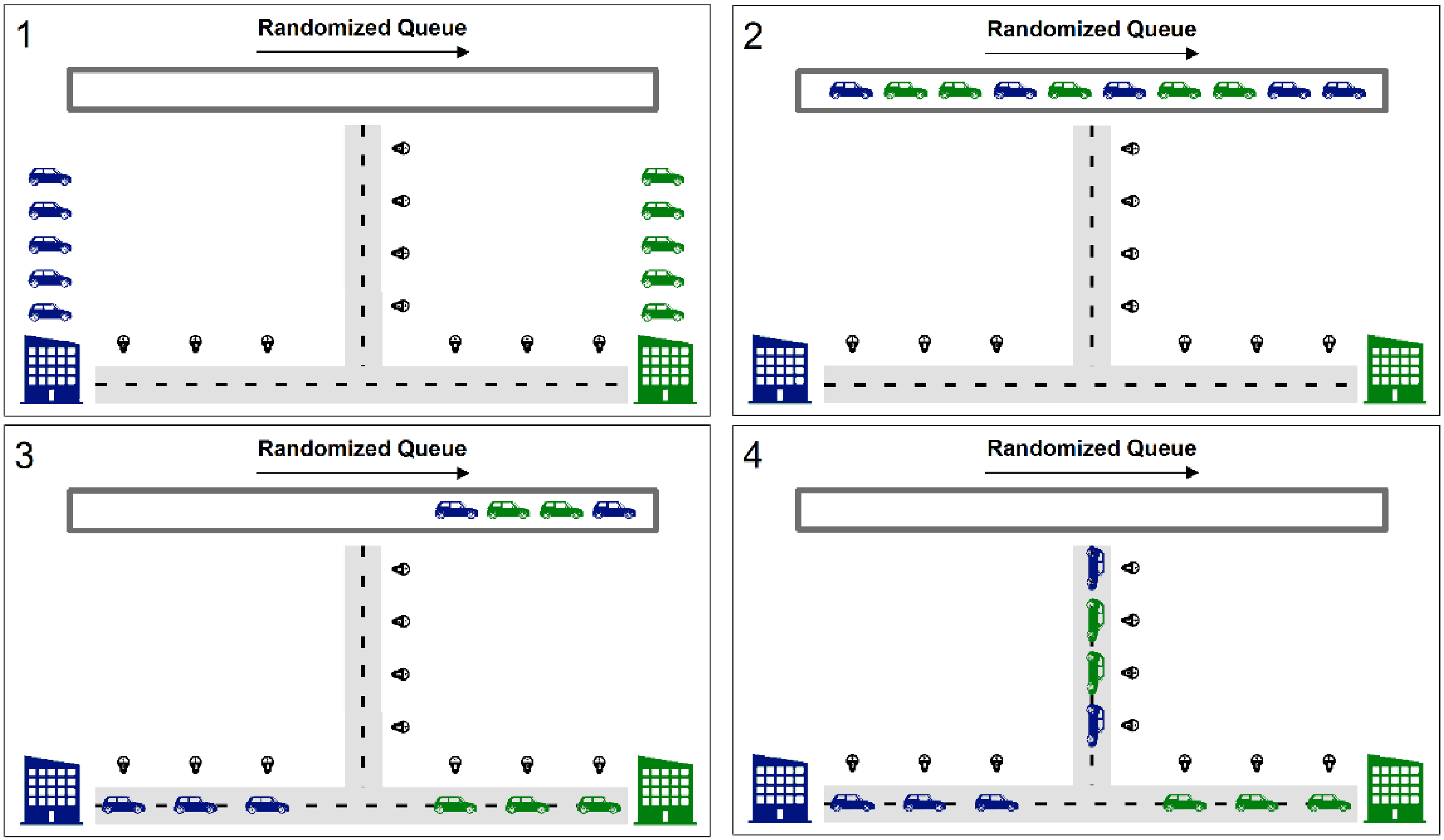
Average cruising times vary substantially with heterogeneity of demand



Conclusions

- *Even for relatively low demand to supply ratios, heterogeneous demand and supply patterns results in patches where parking becomes unavailable for substantial durations of time*
- *Cruising time for the driver who aim at a destination within these patches is defined by the departure rate only, and the probability of very long cruising time is significant*
- *Average occupation rate alone does not indicate parking availability and cruising times, prior to common belief*

Heterogeneity of parking occupation in real cities using PARKFIT algorithm (Levy & Benenson, 2015)



In real cities the clusters of the high-demand buildings are non-random that is, they are much larger (and, usually, located in the center of the city

Bat Yam case study

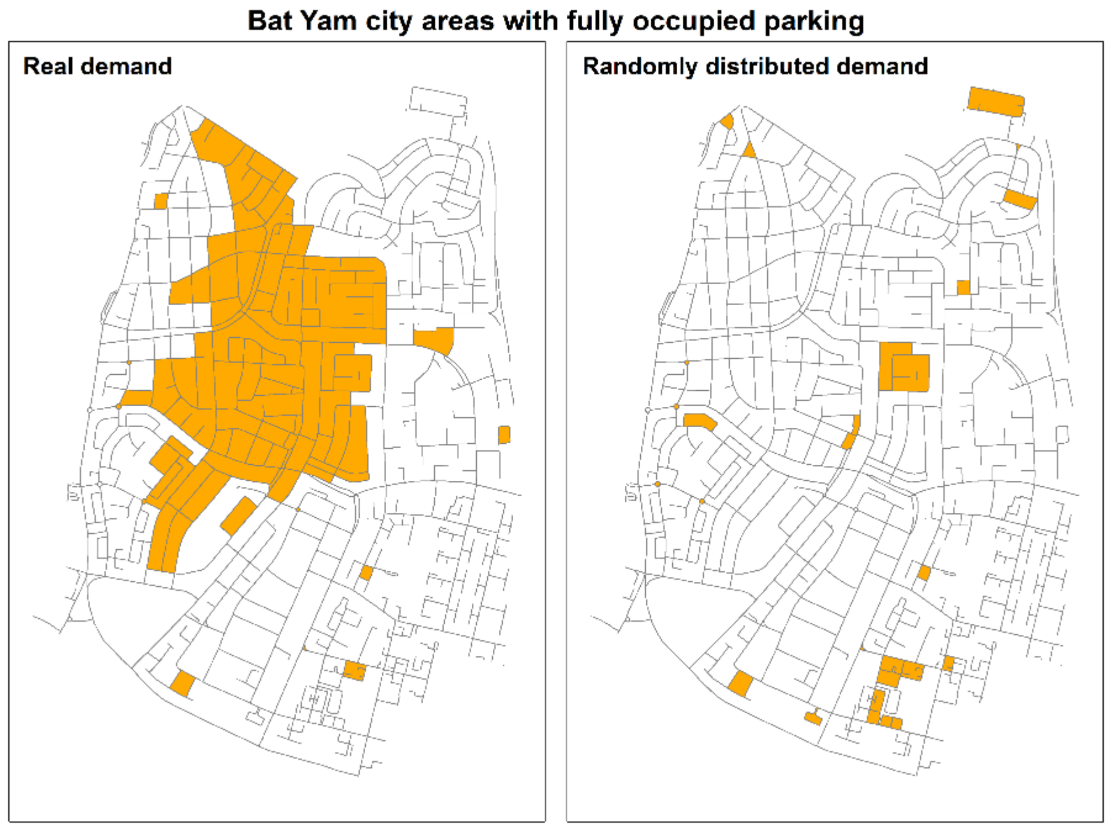
Demand and supply:

- 3,300 destinations

-19,000 drivers competing for parking

- 27,000 on-street and lot parking

q (demand / supply) = 19,000 / 27,000 = 0.7



Policy implications – demand responsive pricing

Tessellation of the urban area should take into account the heterogeneity of demand/supply

Parking Unit

Street segments	Areas
	

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Thank you for your attention