Assessing the potential of crowdsourcing package delivery using mobility data

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Part of the **Crowdsourcing Package Delivery Project**, with Michal Tzur and Tal Raviv, funded by the Ministry of Science, Technology, and Space

Crowdsourcing in the city

- We are interested in evaluating the potential of “**physical crowdsourcing**” in cities
- Especially when **time and space synchronization** is required

Package Deliveries

the final leg of the complete journey of the good before it reaches the customer

Challenges

- Rising expectations for shorter delivery times and lower prices
- Sometimes poor urban infrastructure/ traffic
- Unpredictability in transit and customer availability
- Air pollution

Crowdsourcing Package Deliveries

Utilizing the community movements for package deliveries

entrusters

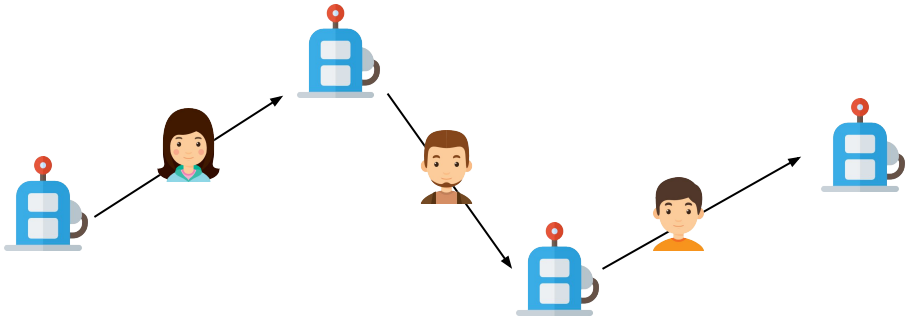
PiggyBee

hitch

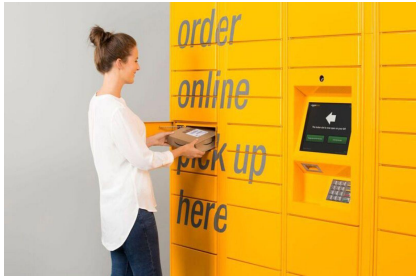
deliv

Different Settings

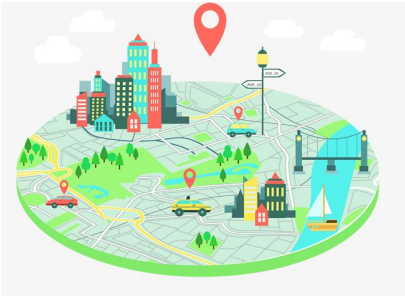
Direct (1) vs. multi-lag transfer (2)



Hand shaking (3) vs. stop points (4)



Intra-urban (5) vs. Inter-urban (6)



Sadilek, Krumm, and Horvitz (2013) - (2), (3), (6)*

Chen et al. (2017) - (2), (4), (5)

McInerney et al. (2013) - (2), (4), (6)

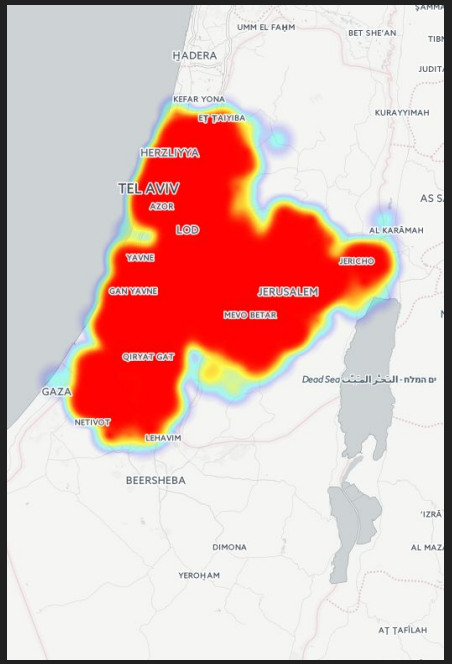
Arslan et al. (2016) - (1), (3), (5)

What are we interested in?

- How can different system designs affect its capacity?
- What is the potential of such a system in terms of:
  - Coverage
  - Delivery durations
  - Number of hops
  - Storage times
  - Geographical differences

Data Analysis

Mobile Phone Data as a Proxy

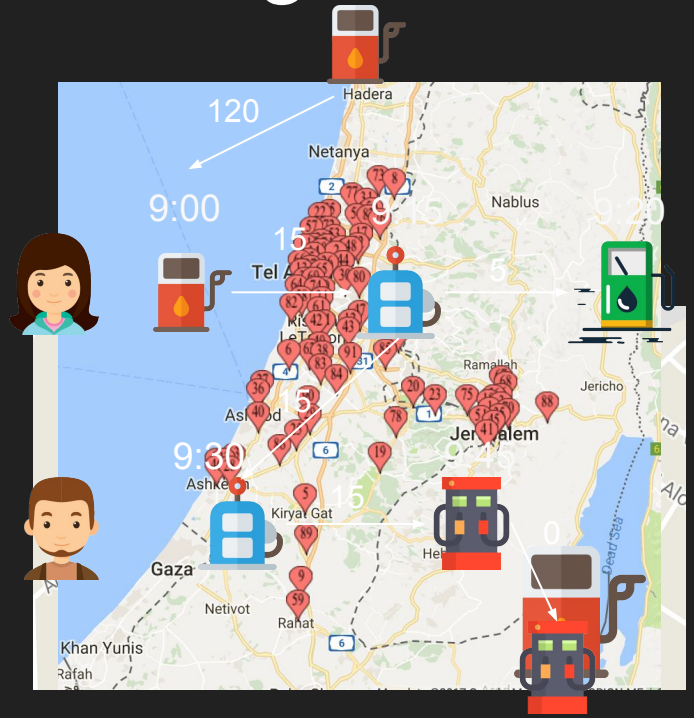


- one-month data extracted of **anonymized** waypoints of **Israeli mobile phone users** from 2013

We started with:

- **~800 GB** of data
- **1.8M distinct users**

Trajectory Mining



- **Trajectory extraction**

Trajectory Tr is a sequence of points pertaining to one trip consisting of longitude, latitude and a timestamp

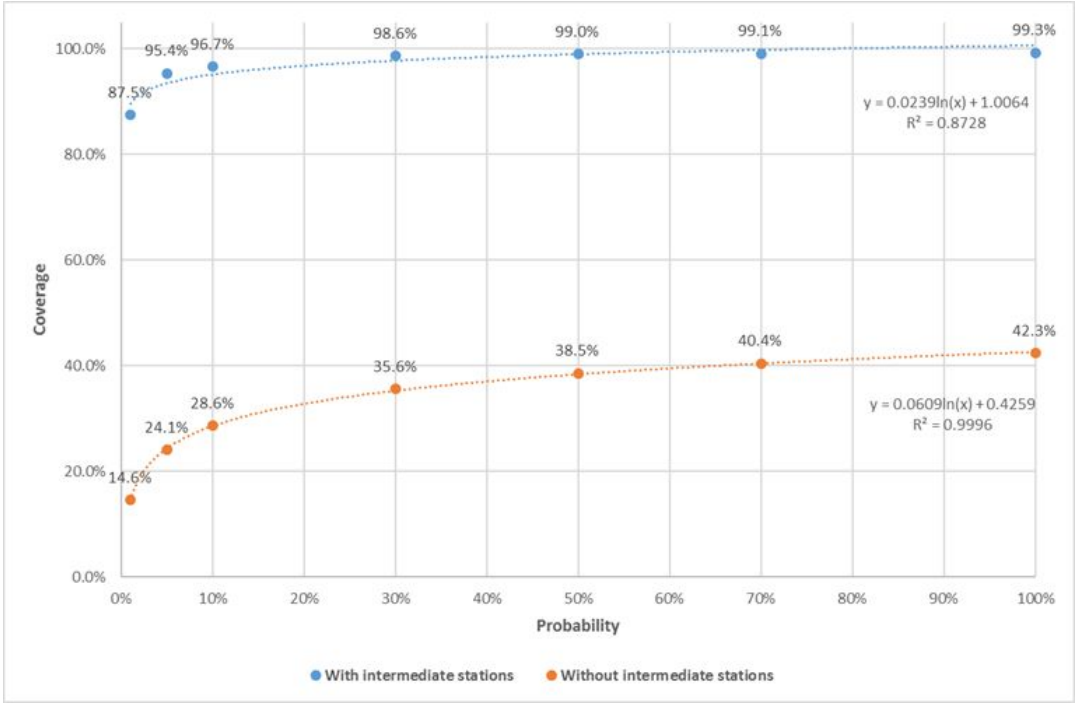
- Stay point detection
- **91 gas stations as our stop points**
- **Finding gas stations along the trajectories' paths**
- **Graph modeling for packages' potential transitions**

Results

Probability	Mean number of potential transfers	Mean number of unique users
100%	1.9M	465K
70%	1.3M	410K
50%	954K	358K
30%	573K	280K
10%	190K	139K
5%	95K	80K
1%	19K	18k

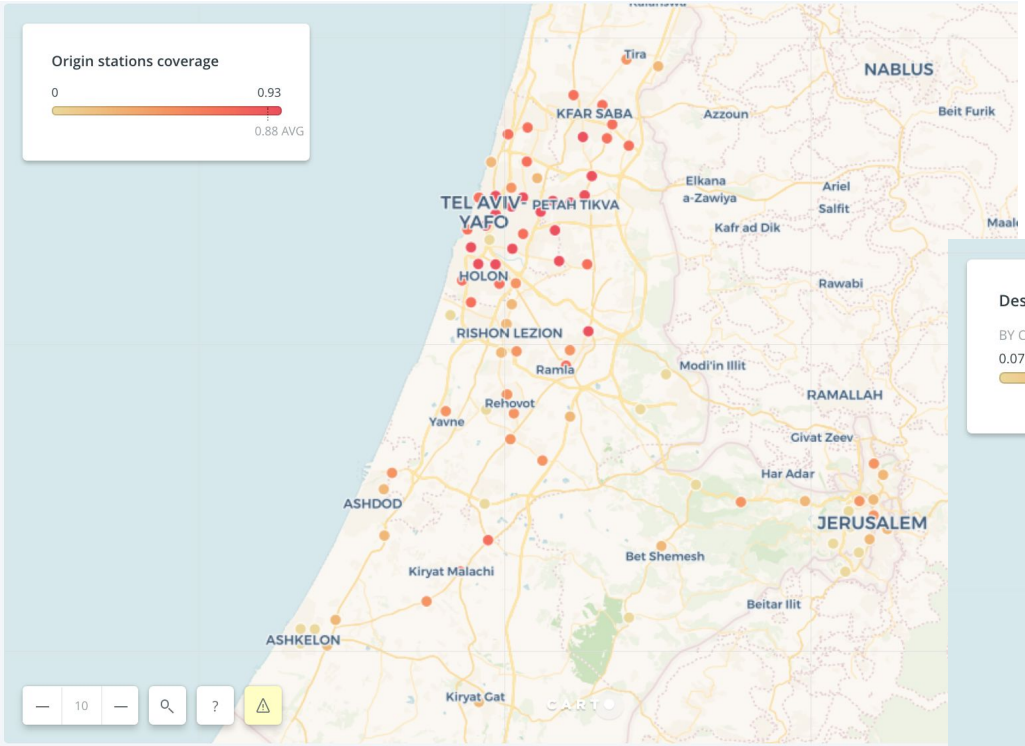
Coverage

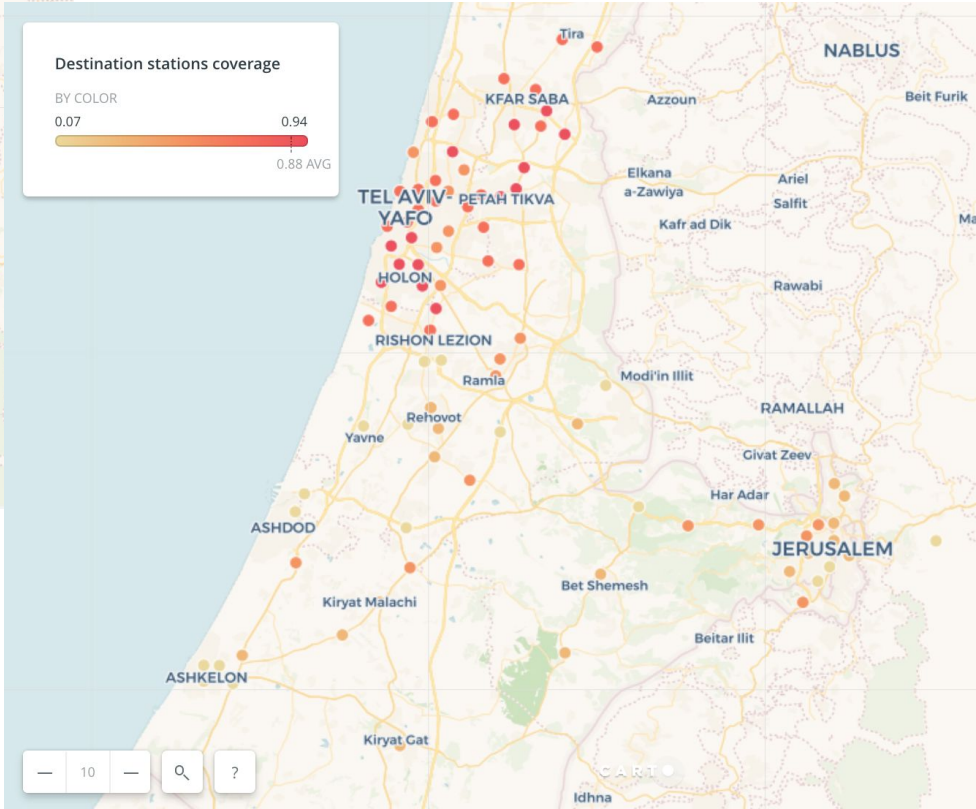
Percentage of simulated origin-destination requests with a path



Probability - the probability a user will want to transfer a package (uniform distribution)

Coverage Probability = 1%





Average Durations (shortest paths)

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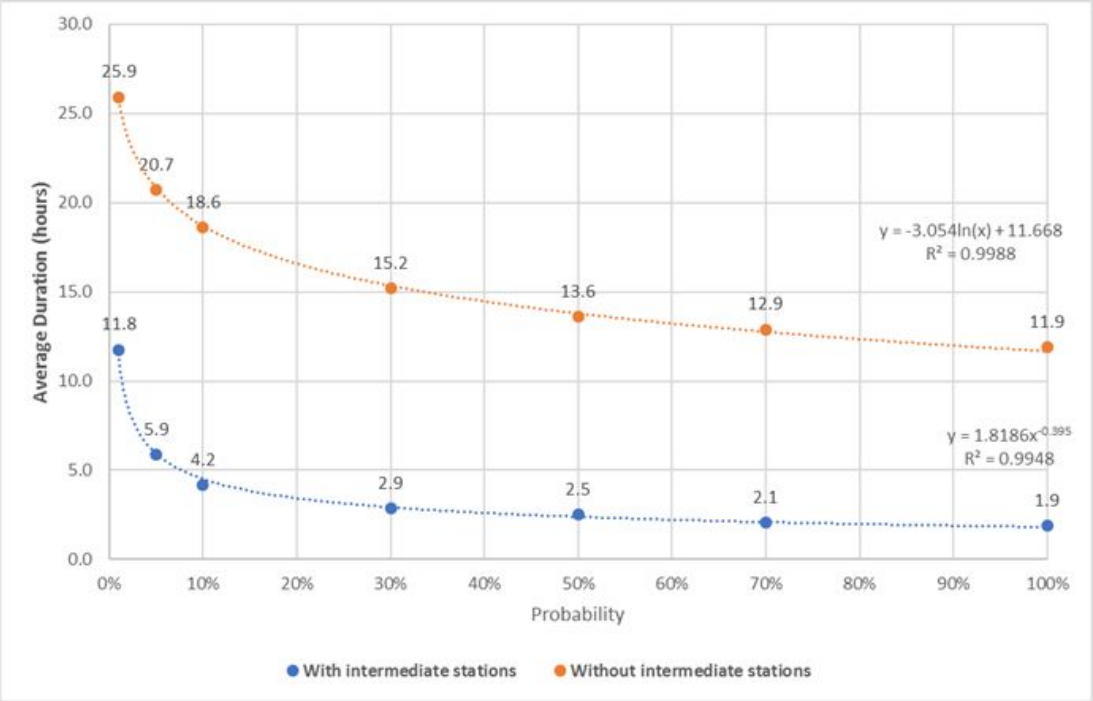

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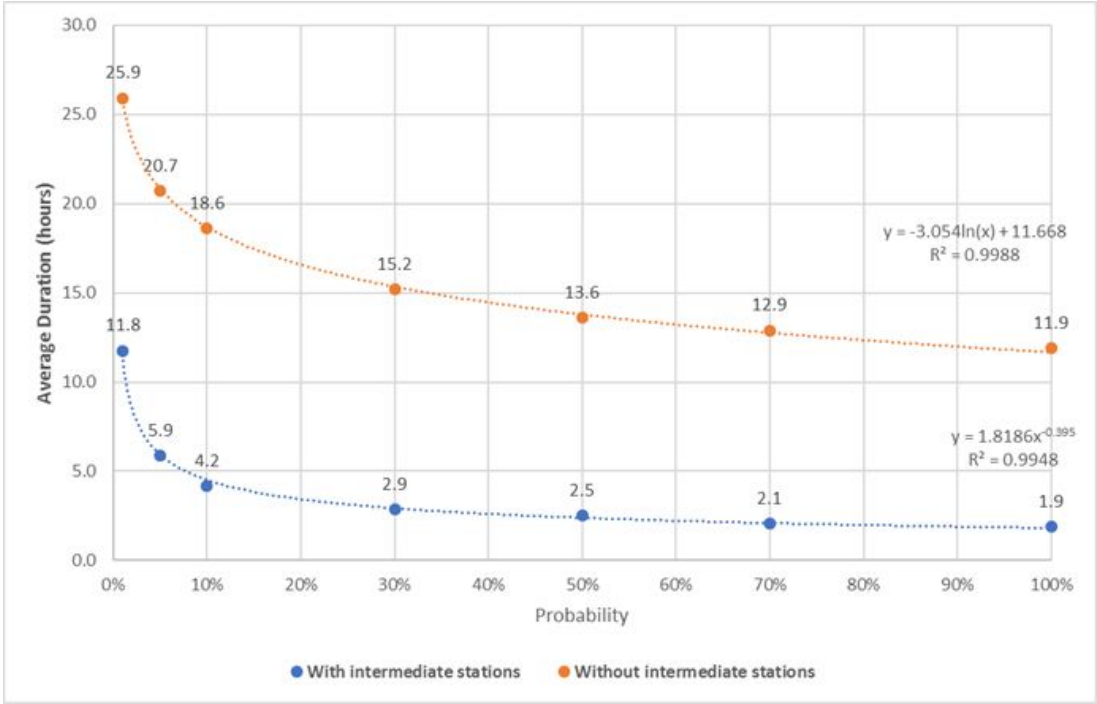

Mean Durations - standard deviations

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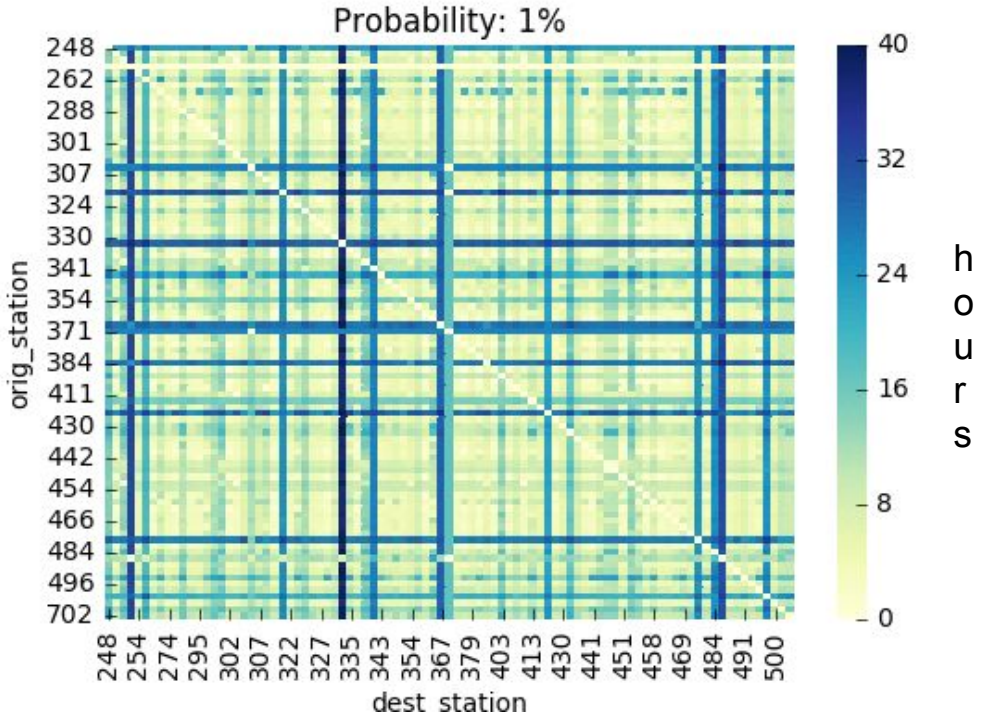
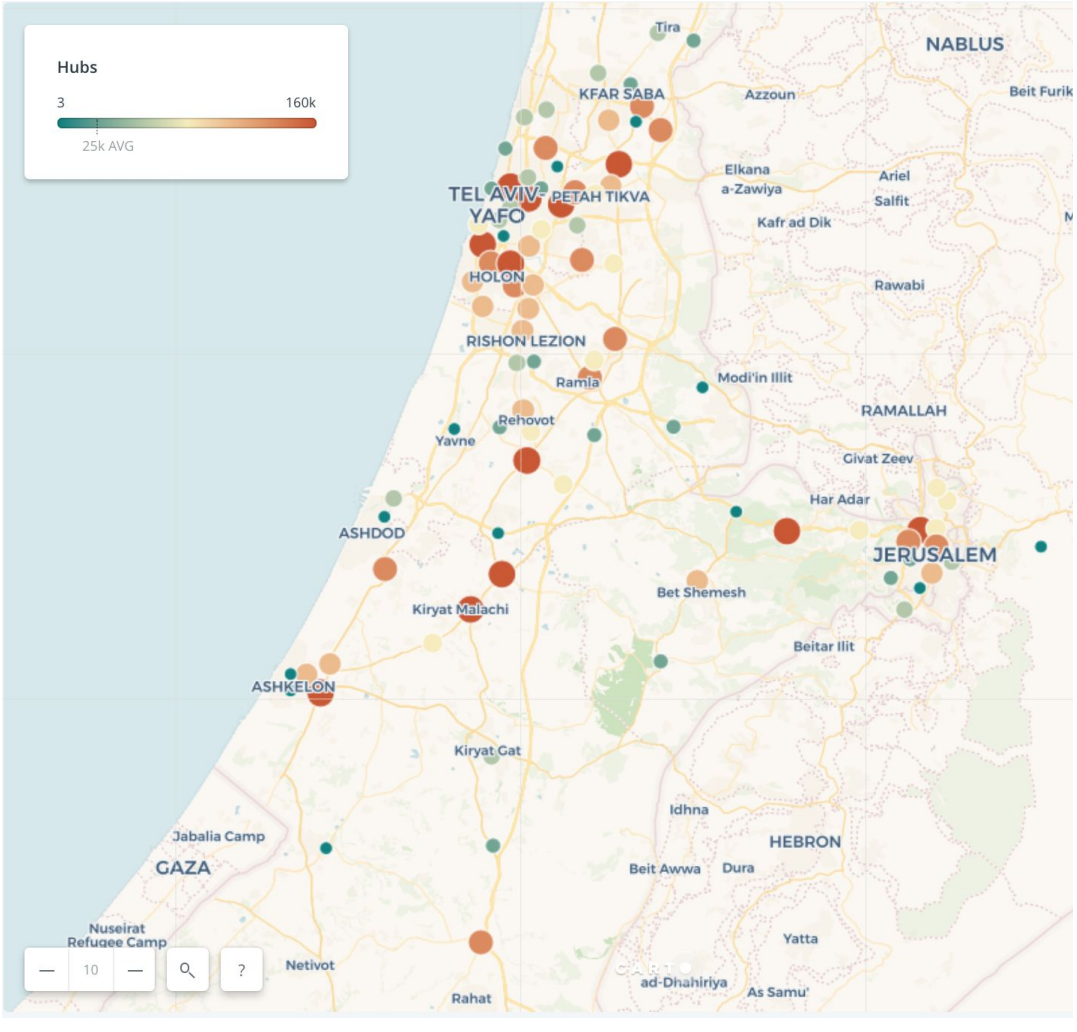
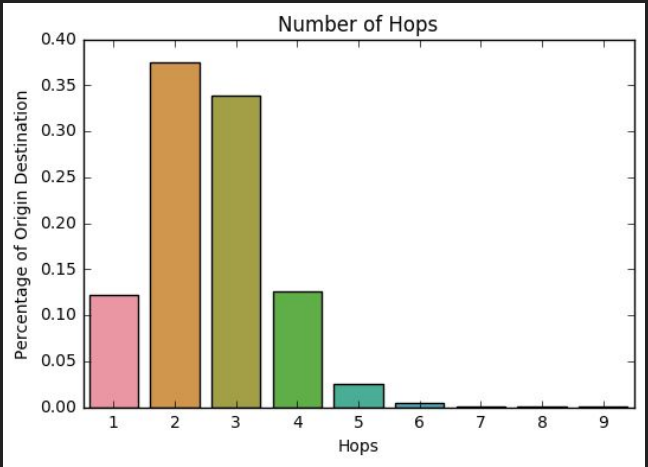


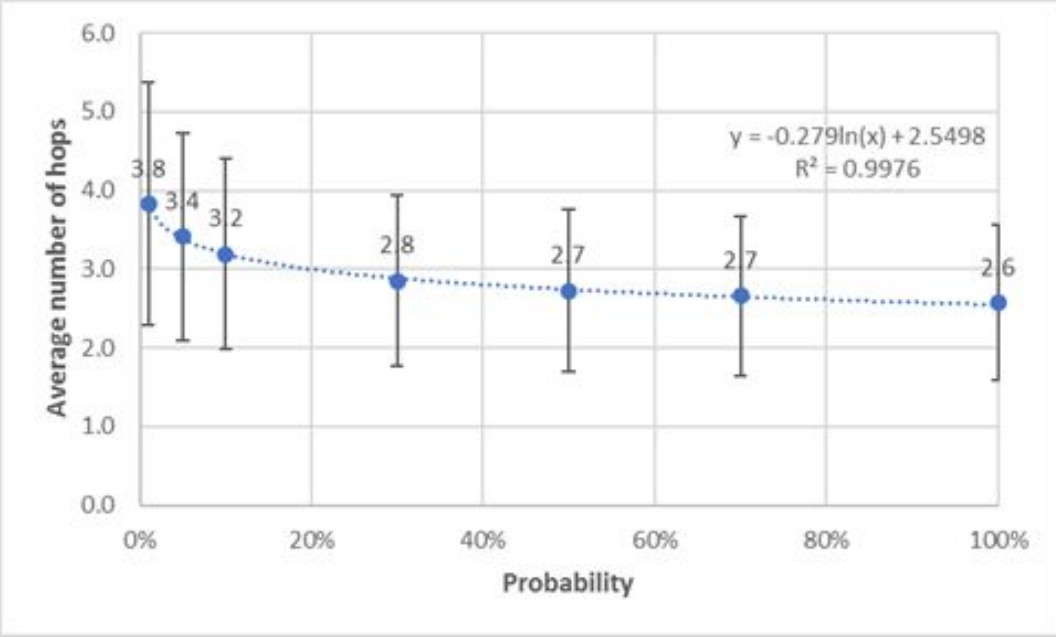
Hubs


Hubs
3
160k
25k AVG
Tira
NABLUS
KFAR SABA
Azzoun
Beit Furik
Elkana
a-Zawiya
Ariel
Salfit
TEL AVIV-YAFO
PETAH TIKVA
Kafr ad Dik
HOLON
Rawabi
RISHON LEZION
Ramla
Modi'in Illit
RAMALLAH
Rehovot
Yavne
Givat Zeev
Har Adar
ASHDOD
JERUSALEM
Bet Shemesh
Kiryat Malachi
Beitar Illit
ASHKELON
Kiryat Gat
Idhna
Jabalia Camp
HEBRON
GAZA
Beit Awwa
Dura
Nuseirat
Refugee Camp
Yatta
Netivot
ad-Dahiriya
As Samu'
Rahat
10

Number of Hops

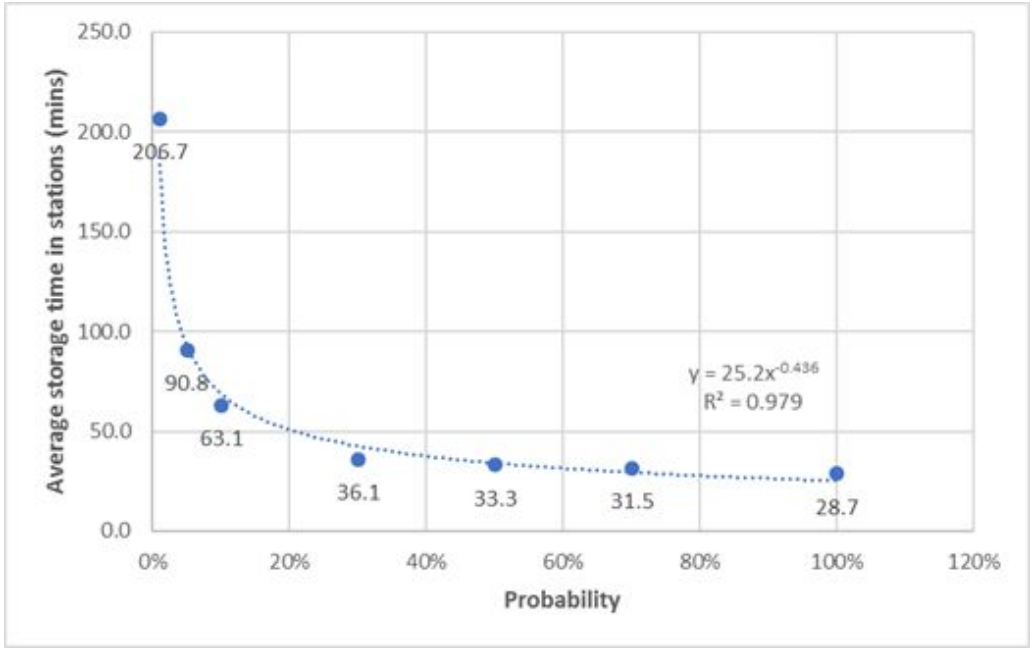
How many users are taking part in the delivery?





Storage Durations

For all probabilities, in more than 97% of time, the storage duration in a station is less than 24 hours



Summary

- Much better performance in terms of coverage and delivery durations when enabling the setting of intermediate stations
- Both the coverage and the delivery durations are not highly sensitive to different network sizes (probabilities)
- A framework for real data simulation of crowdsourcing applications

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