Welcome to

DS504/CS586: Big Data Analytics --Introduction & Logistics

Prof. Yanhua Li

Time: 6:00pm –8:50pm Mon. and Wed.
Location: AK232
Fall 2016

Project I

- Teams

- Timeline and Evaluation
  - Proposal: Week 3, 9/8
  - Methodology: Week 4, 9/15
  - Empirical Results: Week 5, 9/22
  - Introduction: Week 6, 9/29
  - Conclusion, Abstract: Week 7, 9/29
  - Final Report and Presentation: Week 8, 10/13

- Discussions

Growing Charging Station Networks with Trajectory Data Analytics

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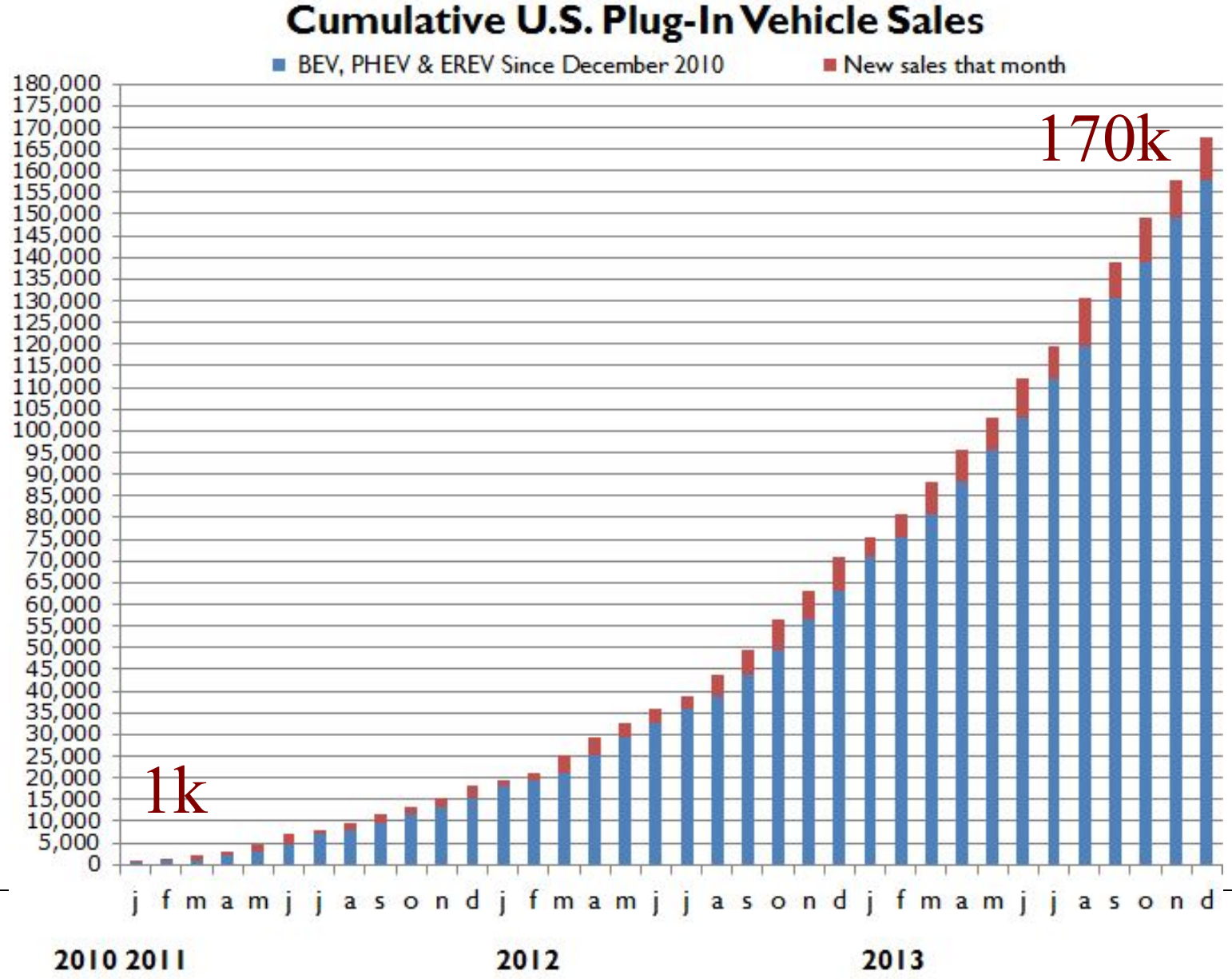
Growth of Electric Vehicles



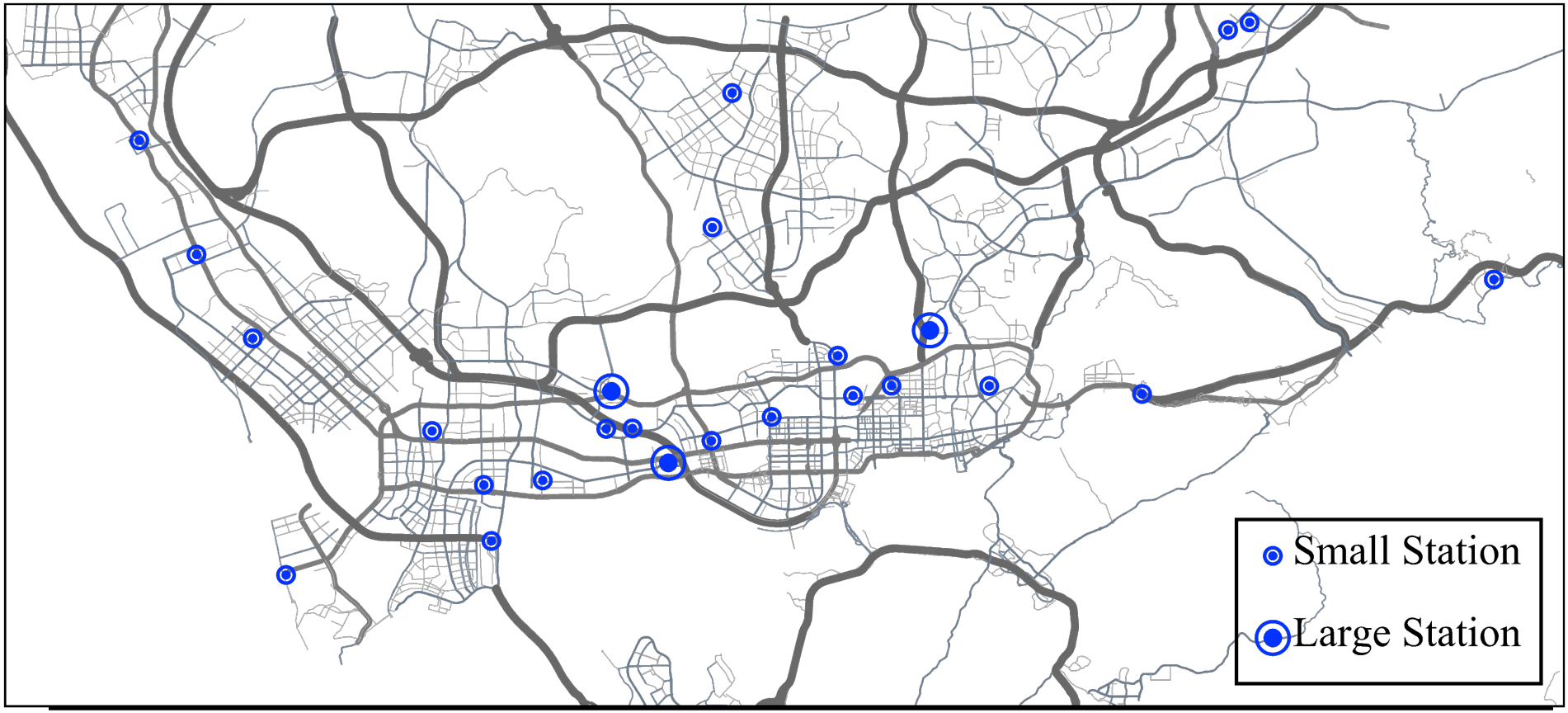
http://www.energyandcapital.com/articles/electric-car-market-growth-soars-in-2013/4173

Charging Station Deployment

- Electric Vehicles:
  - Green transportation:
    - Switching to EVs, 42% reduction in CO_2 emissions
  - Cost efficiency:
    - Fuel (electricity) costs are much lower
- Statistics in Shenzhen, China: (by 2013/11)

	Gasoline Car	Electric Car
Refueling Time	3~5 minutes	1.5~2 hours
Kilometers	Around 600km	Around 200km
Number of cars	2.5 million	2,000 (780 EV taxis)
	Gas Stations	Charging Stations
Number of stations	270	25
Seeking time	2 minutes	4 minutes
Waiting time	1 minute	0 ~ 1.5 hours

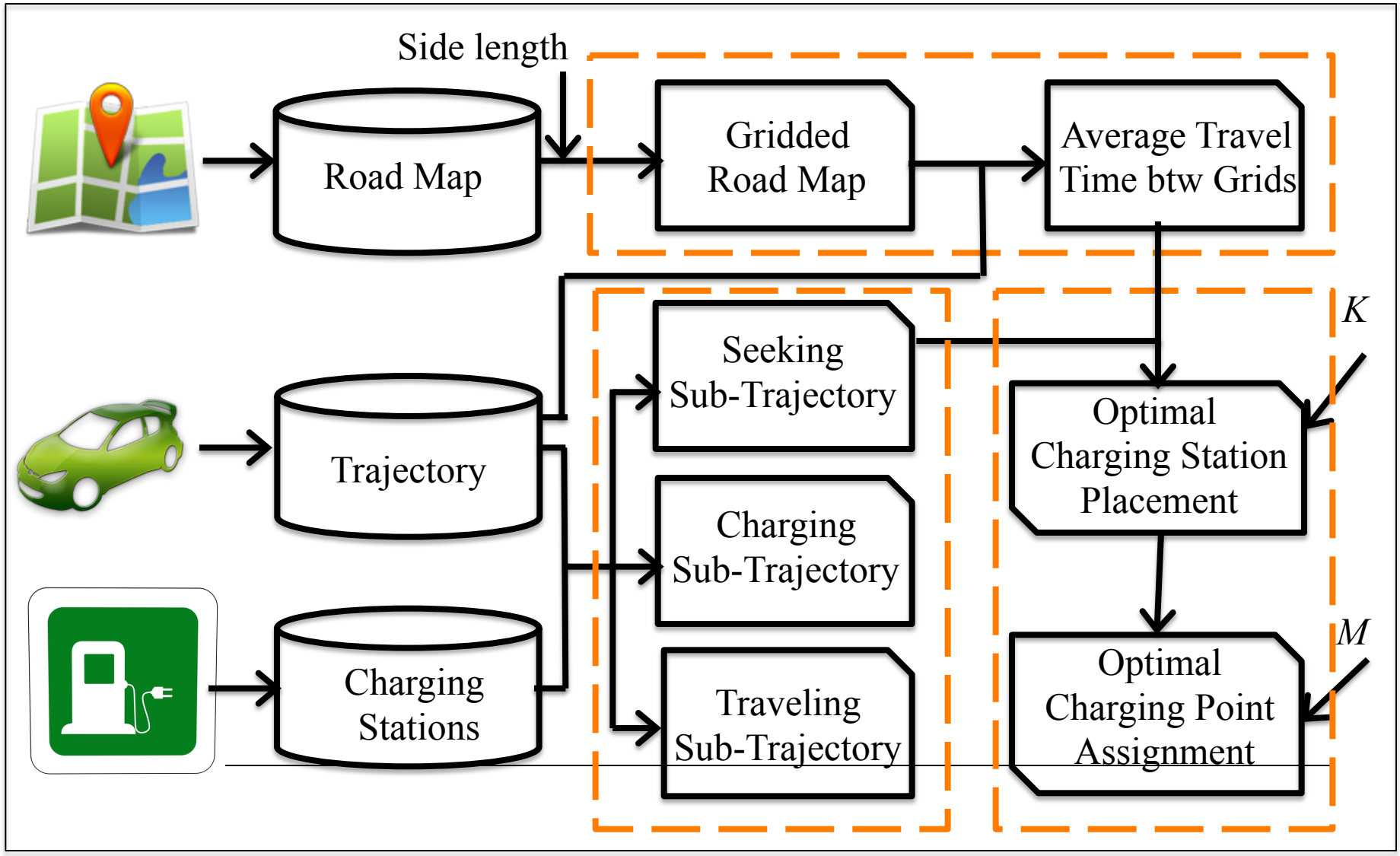
Current Station Geo-Distribution



Challenges

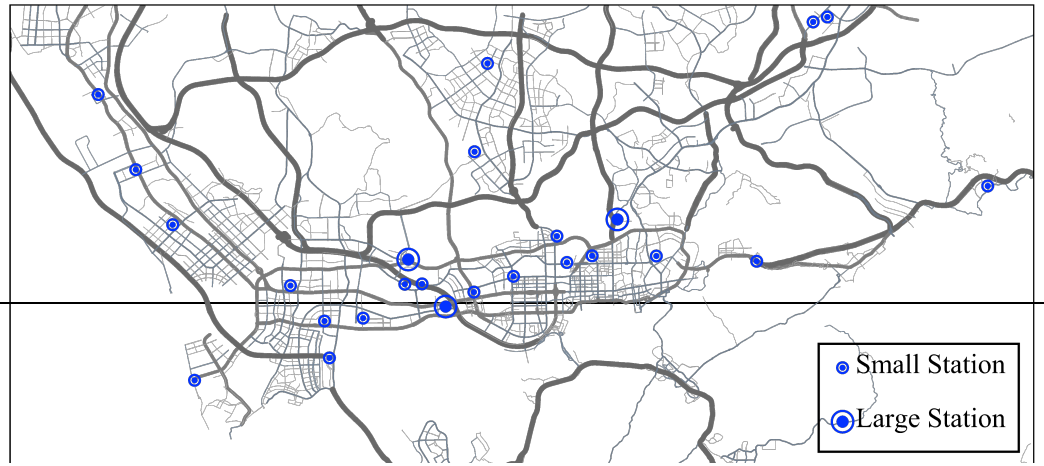
How to deploy charging stations to meet the increasing needs?

Optimal Charging Station Deployment (OCSD)

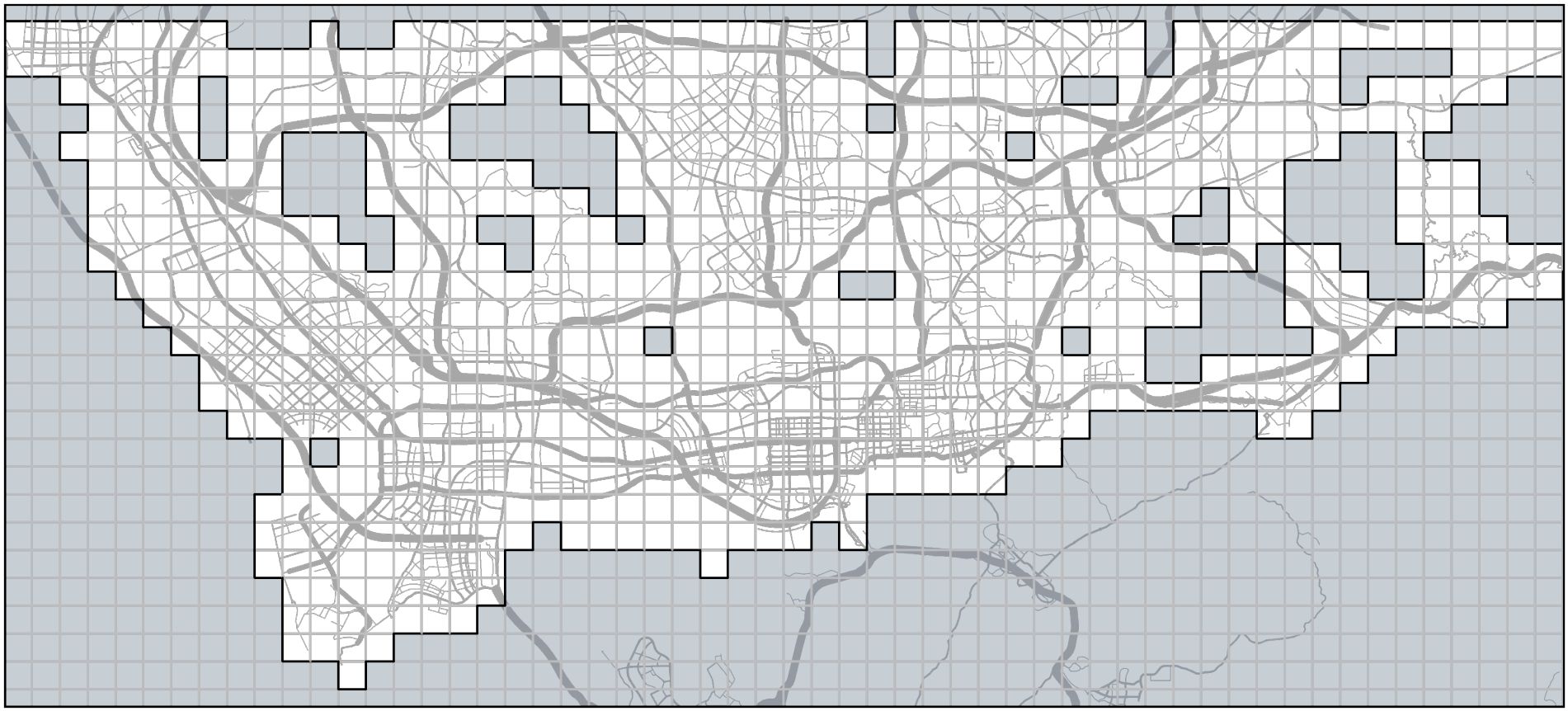


Input Data Description

- EV Trajectory Data:
  - Source: EV taxi GPS in Shenzhen
  - Duration: November 1st–30th, 2013.
  - Size: 23,967,501 GPS records of 490 EV taxis
  - Sampling Frequency: 40 seconds.
  - Format: Taxi ID, time, latitude, longitude, load
- Road Map and Charging Station Information:



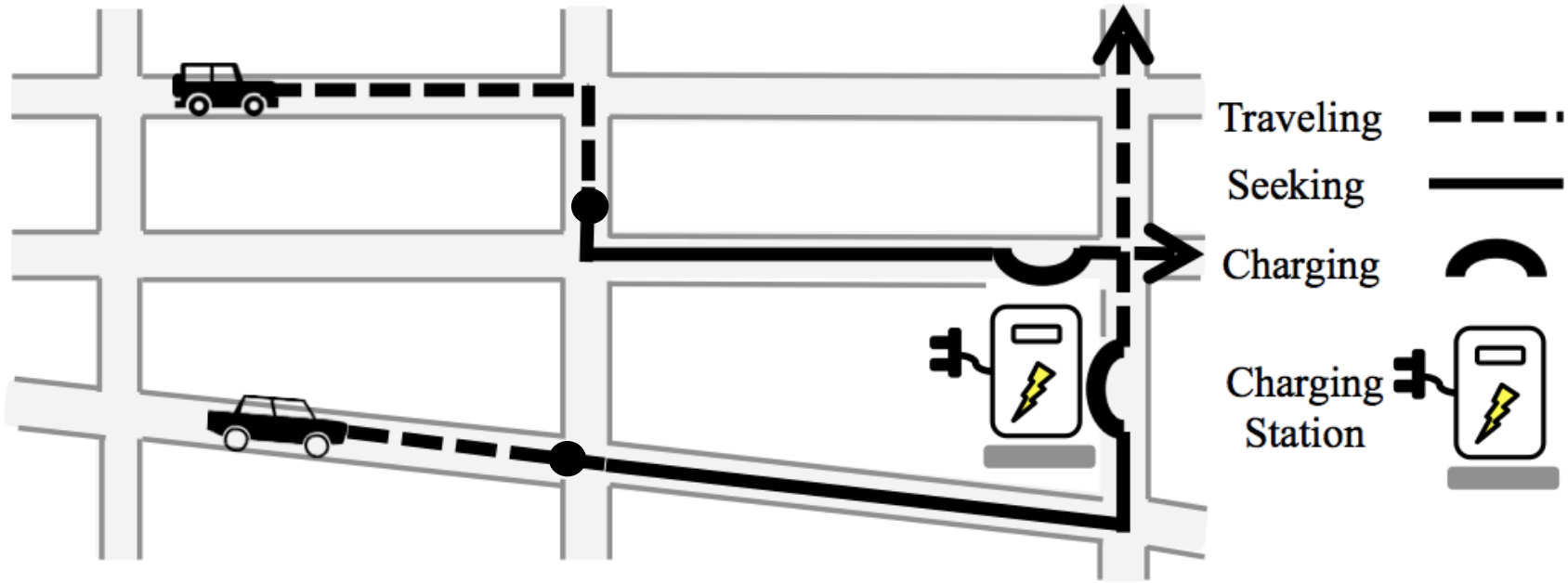
Stage 1: Road Map Gridding



- Given a side length s=0.01°
  - 1508 grids are obtained
  - 760 grids are strongly connected by road network

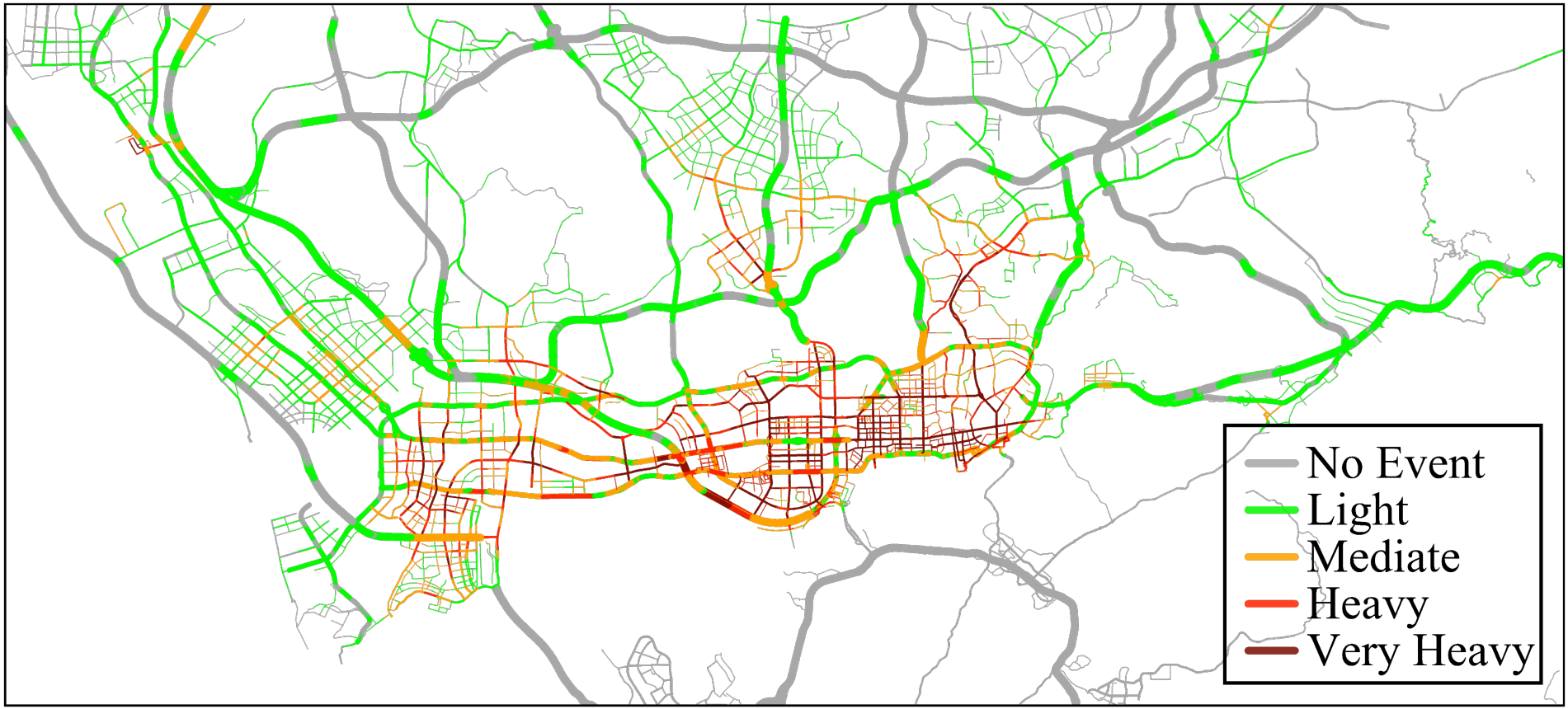
Stage 2: Extracting sub-trajectories

- Traveling sub-trajectory
- Seeking sub-trajectory
- Charging sub-trajectory



Stage 2: Extracting sub-trajectories

- The spatial distribution of seeking events:



Stage 3: Optimal Station Deployment

- Problem definition:
  - Given: L existing stations, Seeking event set,

    K new charging stations, M new charging points
  - How to deploy: Minimize the average time of an EV to find and wait at a charging station

- Two Components:
  - Optimal Charging Station Placement (OCSP)
    - Goal: Minimize the average seeking time
  - Optimal Charging Point Assignment (OCPA)
    - Goal: Minimize the average utilization of charging points

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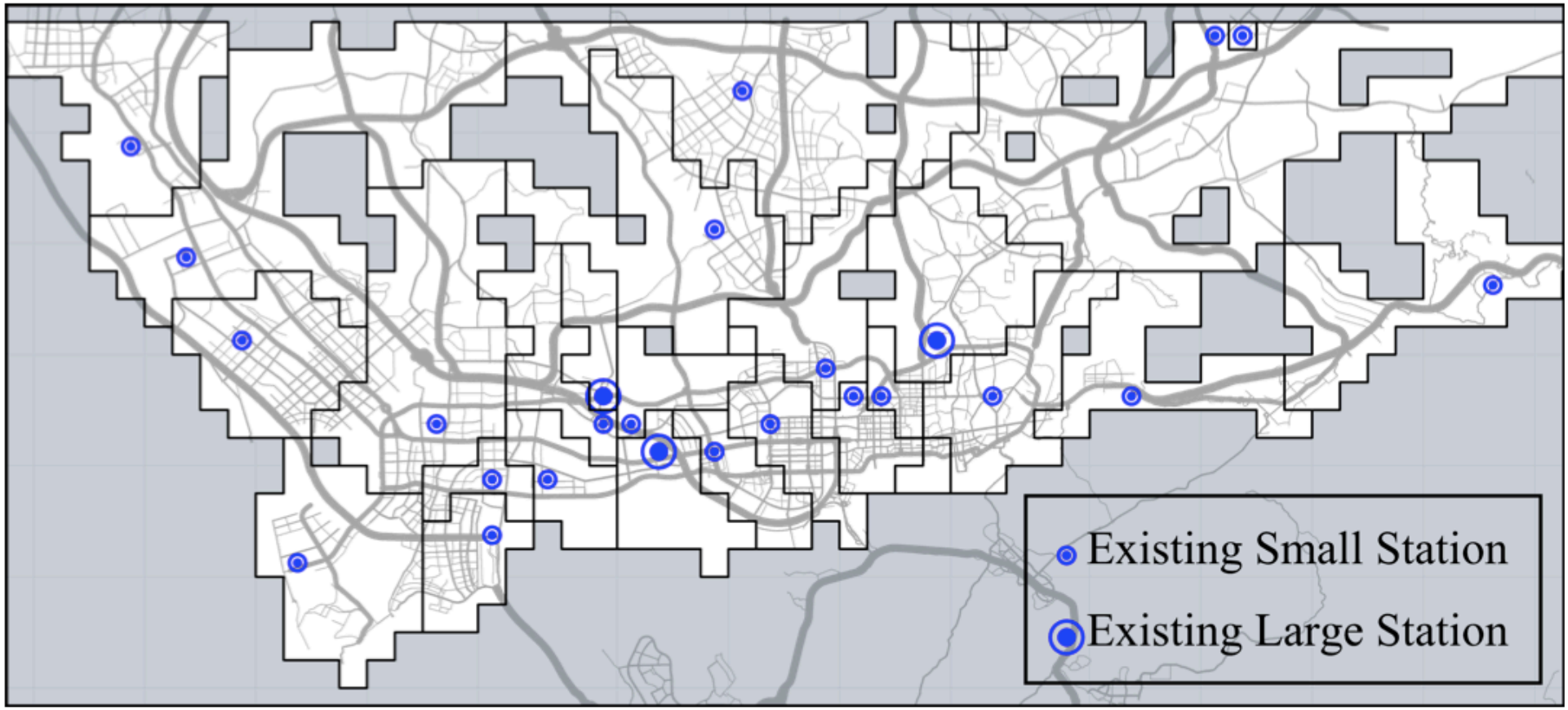
- (proportion of time each charging point is occupied)

Stage 3-I: OCSP

- K-median Problem with Initial medians
  - Assumption: Going to the nearest charging station
  - NP-Hard Problem



Stage 3-I: OCSP

- Formulation:

$$\min : \frac{1}{W} \sum_{g_i \in G} \sum_{g_j \in G} W_i X_{ij} C_{ij}$$

$$\text{s.t.:} \sum_{g_j \in G} X_{ij} = 1, \qquad \forall g_i \in G$$

$$\sum_{g_j \in G} y_j \leq K + L,$$

$$X_{ij} \leq y_j, \qquad \forall g_i, g_j \in G$$

$$X_{ij}, y_j = \{0, 1\}, \qquad \forall g_i, g_j \in G$$

$$y_j = 1, \qquad \forall g_j \in G_L$$

- Approximation Alg:
  - ~~(1) LP-Relaxation~~
  - (2) Rounding

Stage 3-II: OCPA

Formulation:

- Each charging station is an $M/M/(S_\ell + \hat{S}_\ell)$ queue.
- Arriving rate λ_ℓ: average # of per hour seeking events
- Serving rate μ_ℓ average # of per hour served EVs
- Charging point utilization $\rho_\ell = \lambda_\ell/((S_\ell + \hat{S}_\ell)\mu_\ell)$

$$\min_S : \sum_{\ell=1}^{K+L} \frac{\lambda_\ell}{(S_\ell + \hat{S}_\ell)\mu_\ell} \quad \text{s.t.:} \quad \sum_{\ell=1}^{K+L} S_\ell = M$$

Optimal Solution:

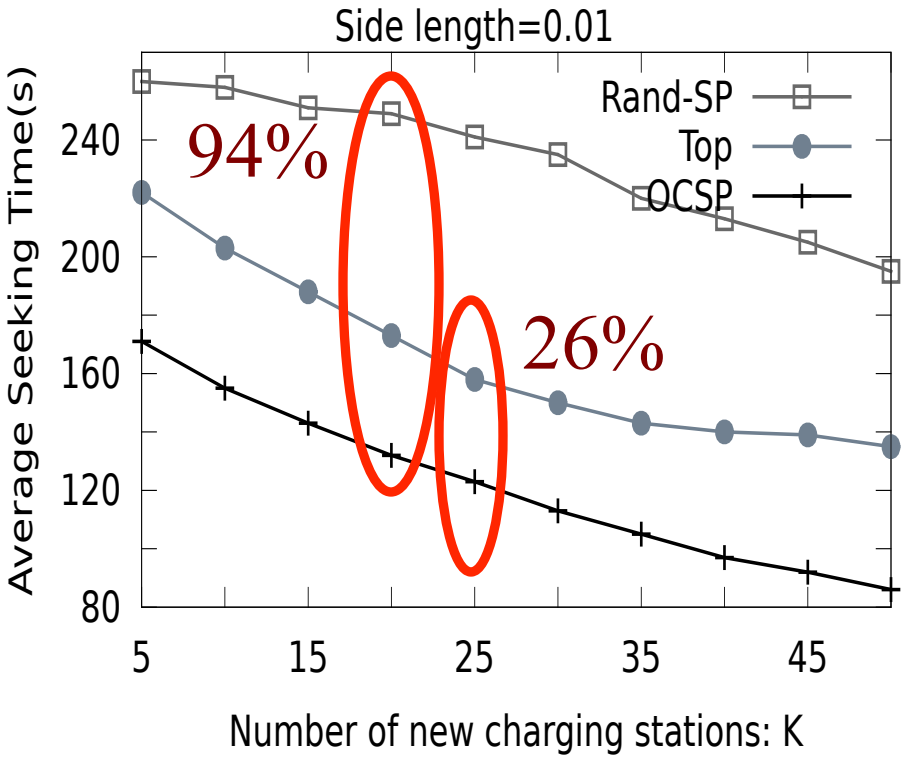
$$S_\ell = (M + \hat{M})\lambda_\ell/(\mu_\ell r) - \hat{S}_\ell$$

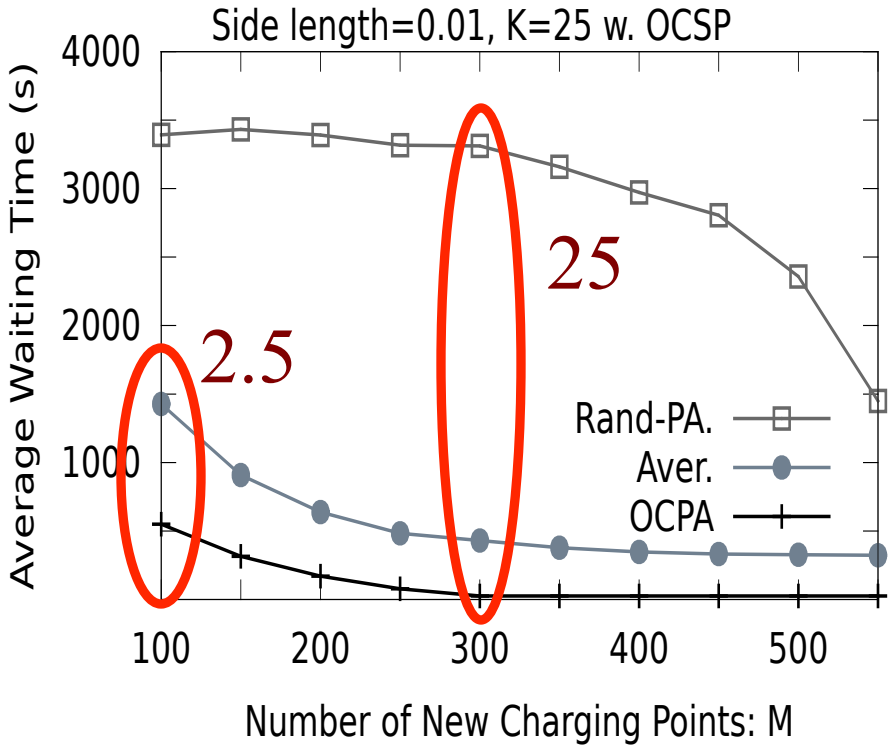
$$\text{with } \hat{M} = \sum_{\ell=1}^{K+L} \hat{S}_\ell \qquad r = \sum_{\ell=1}^{L+K} \lambda_\ell/\mu_\ell$$

Evaluation

- Charging station placement
  - Baselines
    - Rand-SP: Random station placement
    - Top: Top seeking events
  - OCSP algorithm
- Charging point assignment
  - Baselines
    - Rand-PA: Random point assignment
    - Aver.: Average charging point assignment
  - OCPA algorithm

Average Seeking & Waiting Time





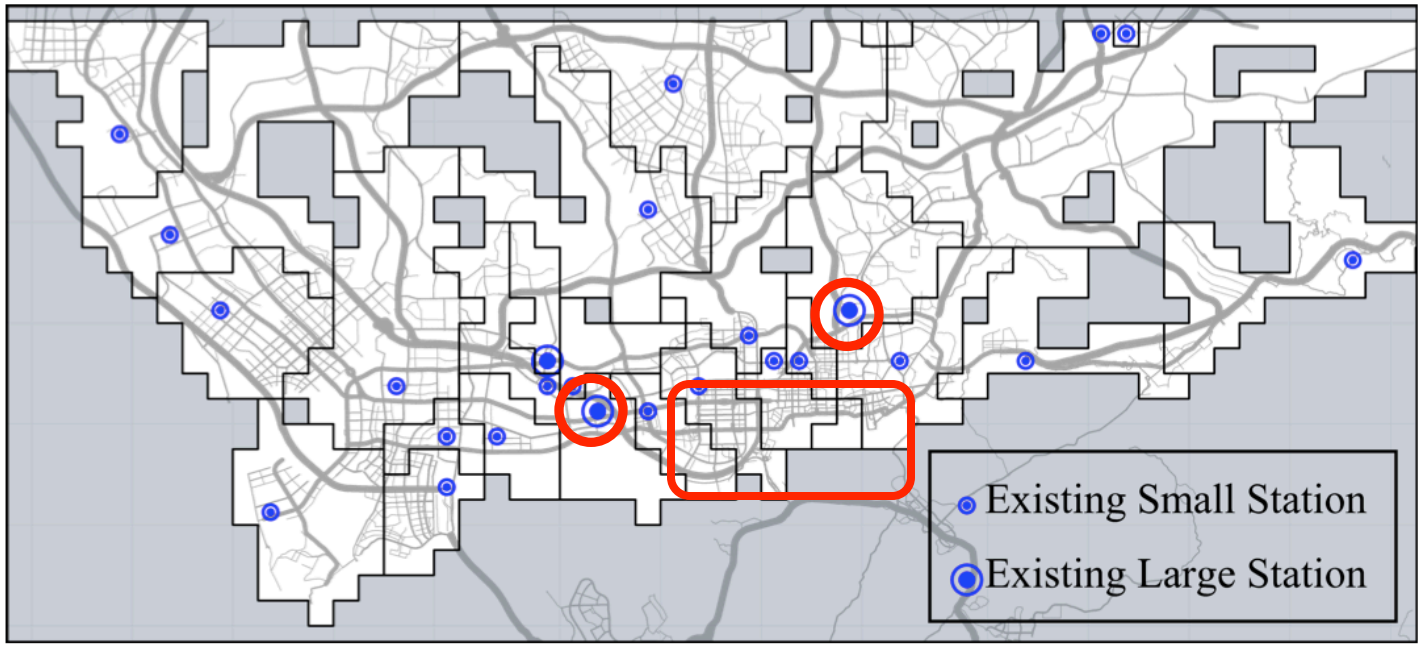
Average Seeking Time:

26%–94% reduction rate

Average Waiting Time:

2.5 to 25 times reduction

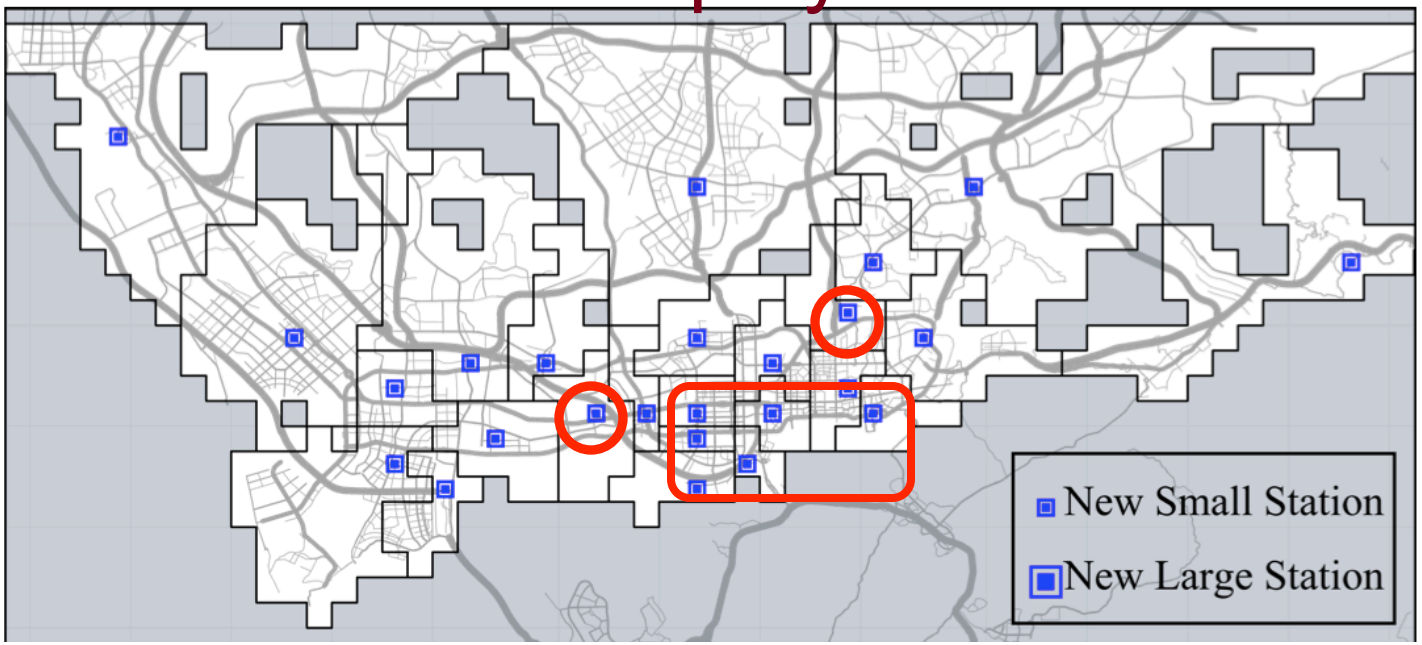
Current Geo-Distribution



Ave Seeking Time: 213s

Ave Waiting Time: 928s (15min)

Redeployment



Ave Seeking Time: 110s

Ave Waiting Time: 11s

Questions?

Next Class: Data Acquisition and Measurement

- Do assigned readings before class
  - Be prepared, read and review required readings *on your own in advance!*
  - *Do literature survey: find and read related papers if any*
  - *Bring your questions to the class and look for answers during the class.*
- Submit reviews/critiques
  - In mywpi before class
  - Bring 2 hardcopies to the class
  - Hand in one copy, and keep one copy with you.

Review Writing:
http://users.wpi.edu/~yli15/courses/DS504Spring16/Critiques.html

- Attend in-class discussions
  - Please ask and answer questions in (and out of) class!
  - Let's try to make the class interactive and fun!