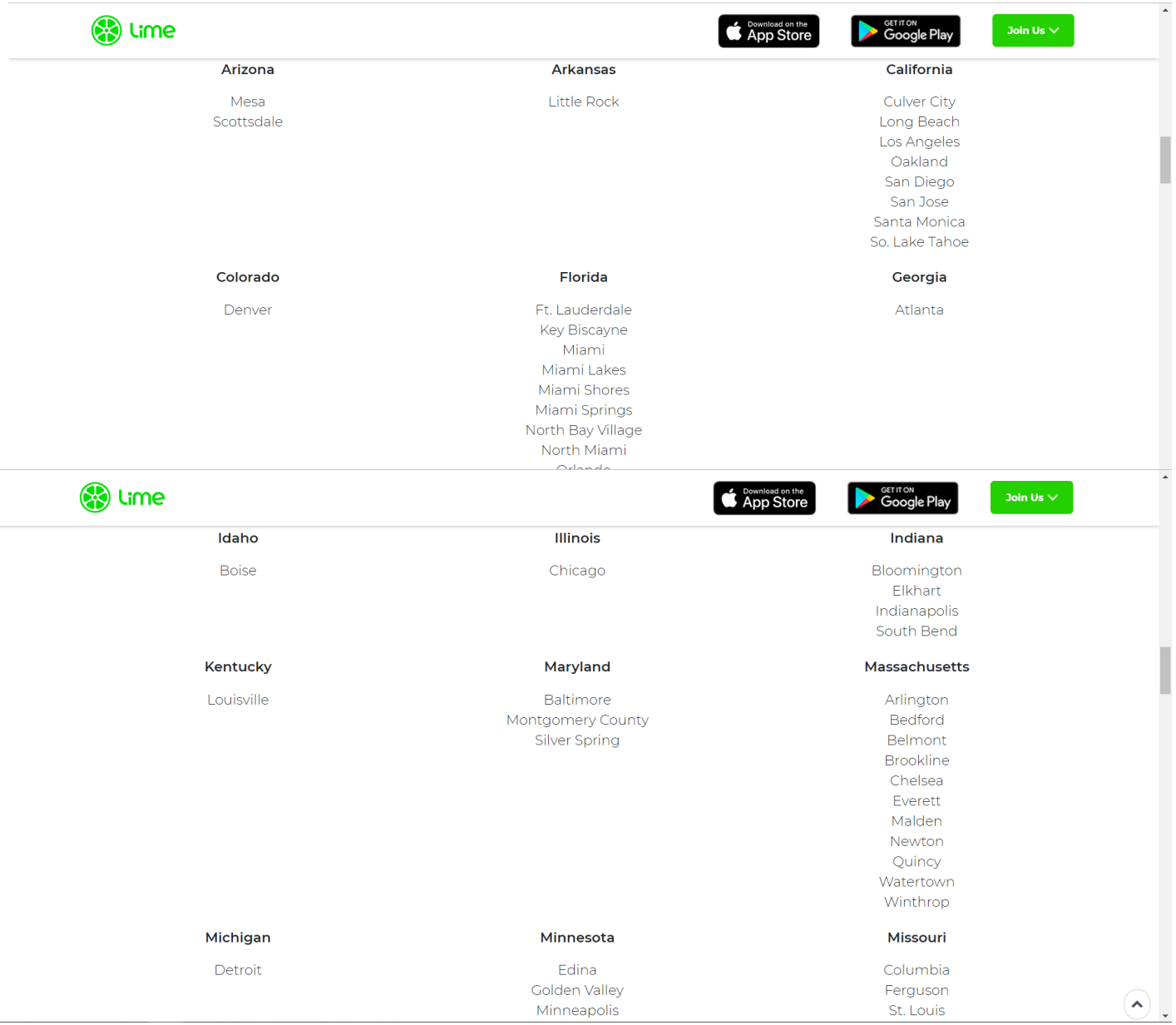
Selecting optimal sites for Lime scooter in Dane County

Ziqian Deng

Introduction to the company

- Lime, formerly LimeBike, is a transportation company based in the United States.
- It runs electric scooters, electric bikes, normal pedal bikes and car sharing systems in various cities around the world.
- Lime is considered as No.1 electric scooter and bike sharing app. …
- “With Lime, you'll never have to worry about traffic or finding a parking station, and you can leave your ride safely at your destination for a fraction of the cost of a taxi or a ride share”

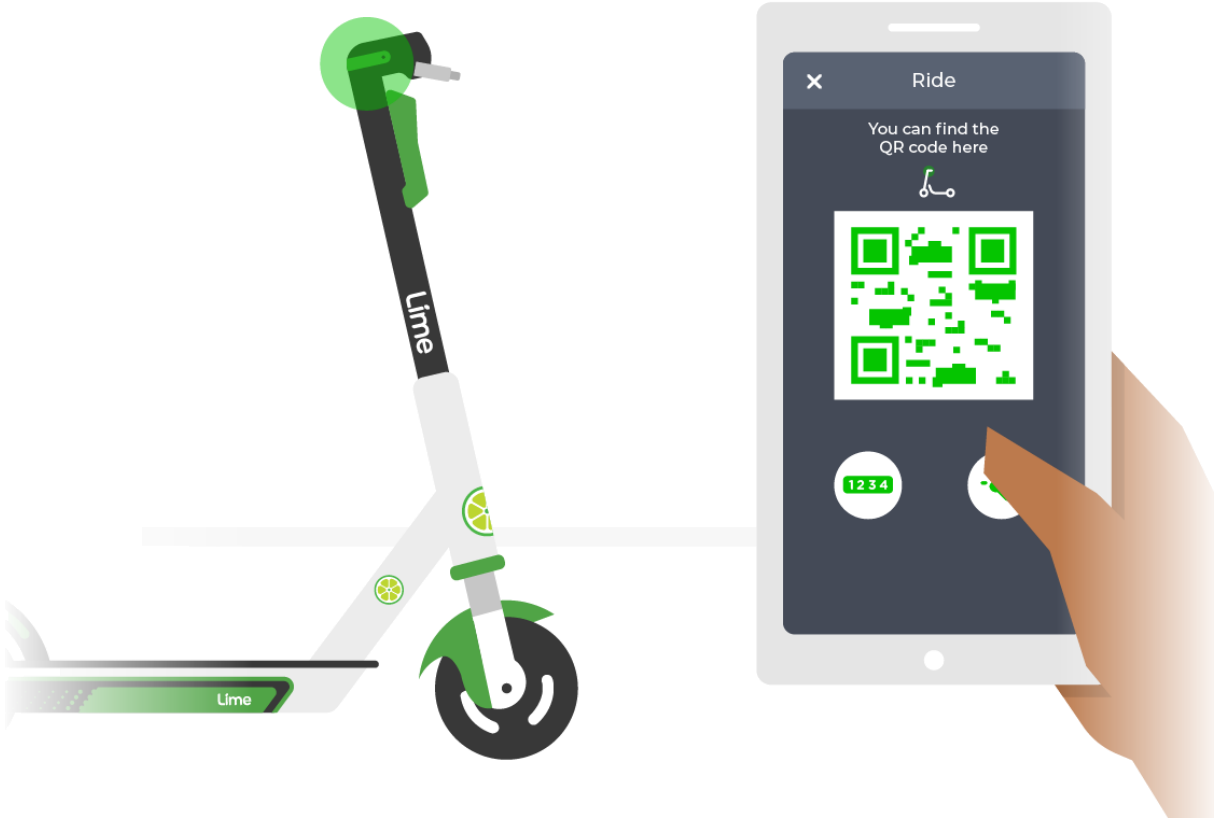
Introduction to the project



- Lime has already covered many cities across the United State, however, it hasn't reached out any city in Wisconsin.
- Since we have witnessed its great popularity, Lime is believed to expanding the business to Wisconsin.
- The goal of the project is to simulate the campaign in Dane County in Wisconsin, to find the potential sites for Lime to arrange the scooters and to build a model to solve the Vehicles Routing Problem for later use.

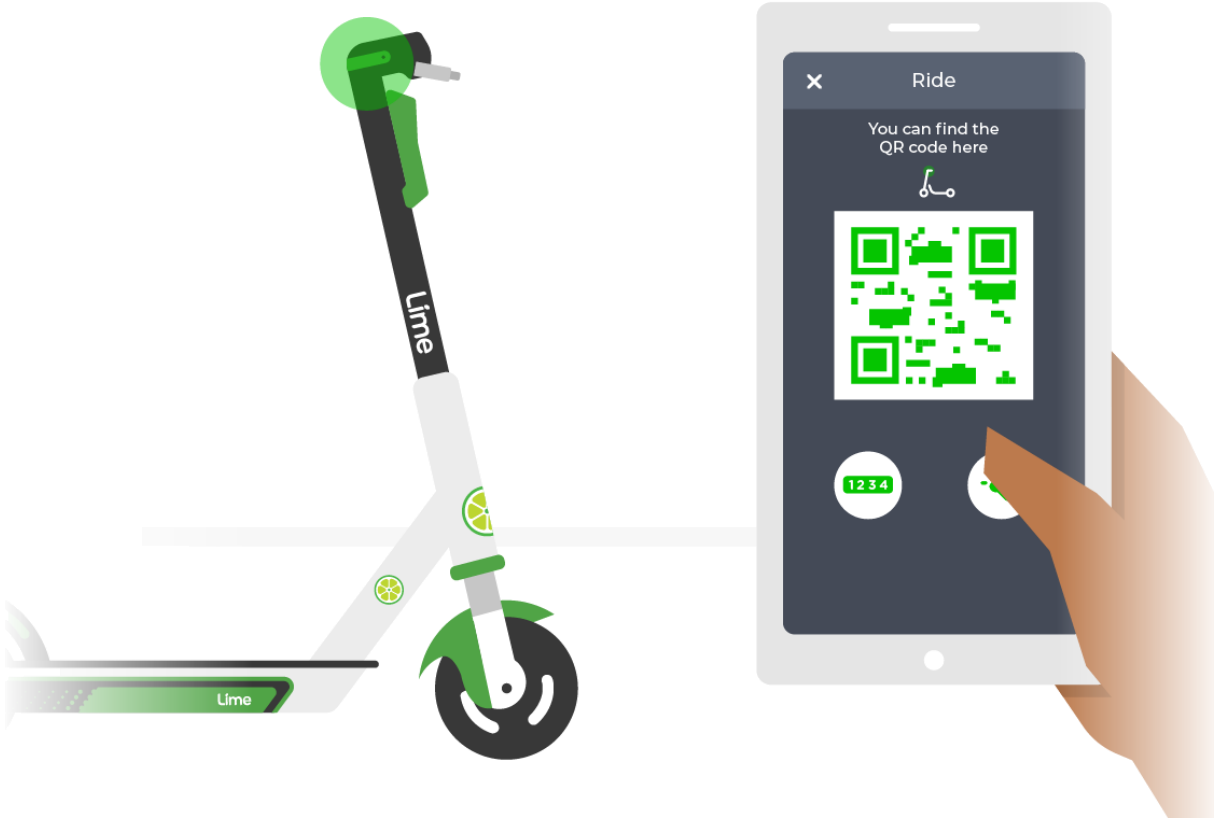
Methodology --- Set Packing Problem

- The major part of the project can be considered as a **Set Packing Problem**.
- First, we need to simulate a list of potential sites in Dane County for Lime scooters
- Then we will set the allocation constraints to separate sites by **at least 0.5** km to avoid cannibalizing demand.



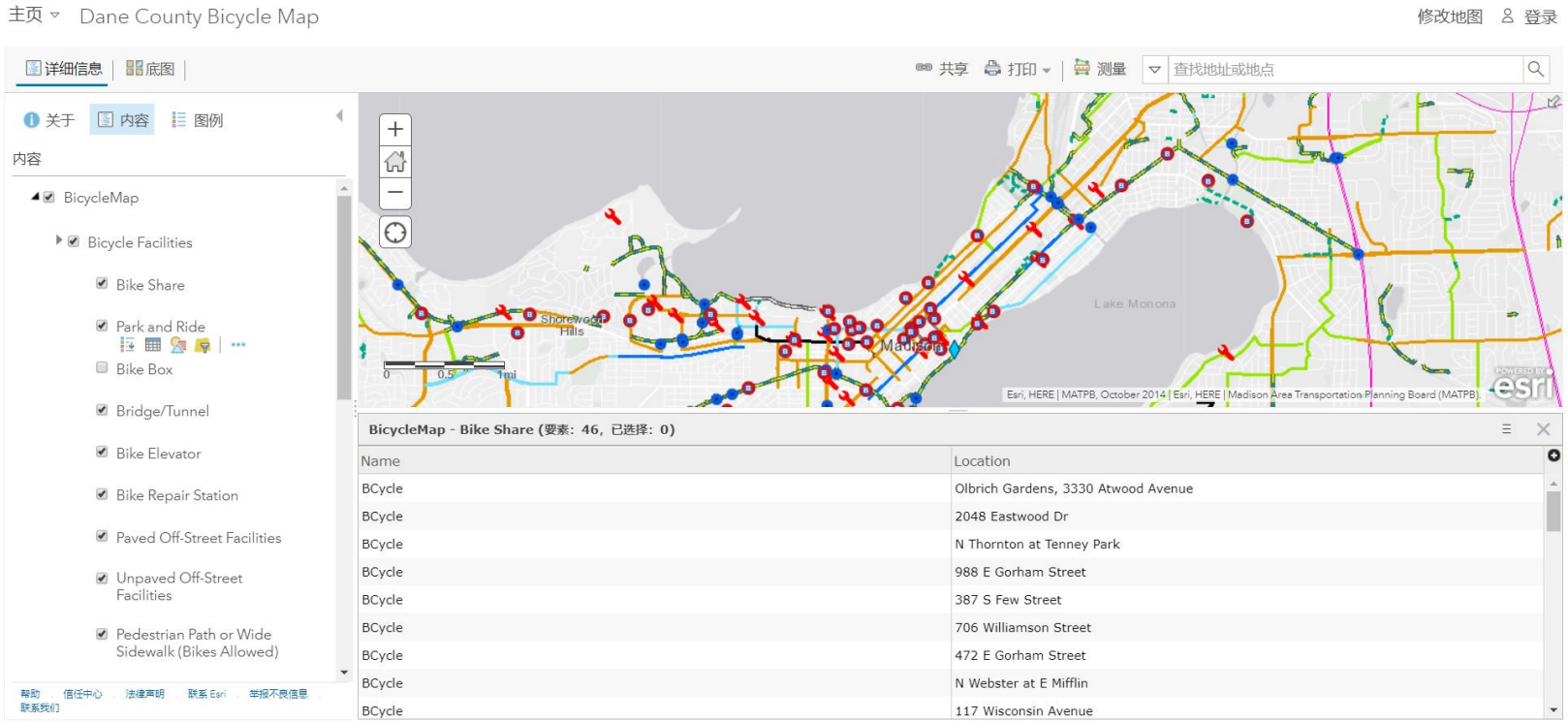
Methodology --- Vehicles Routing Problem

- The other part of the project is a **Vehicles Routing Problem (VRP)**.
- We will use the optimal solution from the first part and solve a simulated VRP for Lime
- The first problem is solved by **Pyomo** and the second one is solved by **Google OR-Tools**.



Set Packing Problem

- **Simulation sites**: To find the potential sites for Lime scooters, we will refer to the BCycle sites in Dane County. https://cityofmadison.maps.arcgis.com/home/webmap/viewer.html?webmap=65608cc71b924f82965b83daaccf99a1
- **Solver**: Second, we need to leverage python packages to get the coordinates for the sites, calculate the distance between every two sites, and solve the set packing problem under the constraints that the sites need to be separated **by at least 0.5 km**.



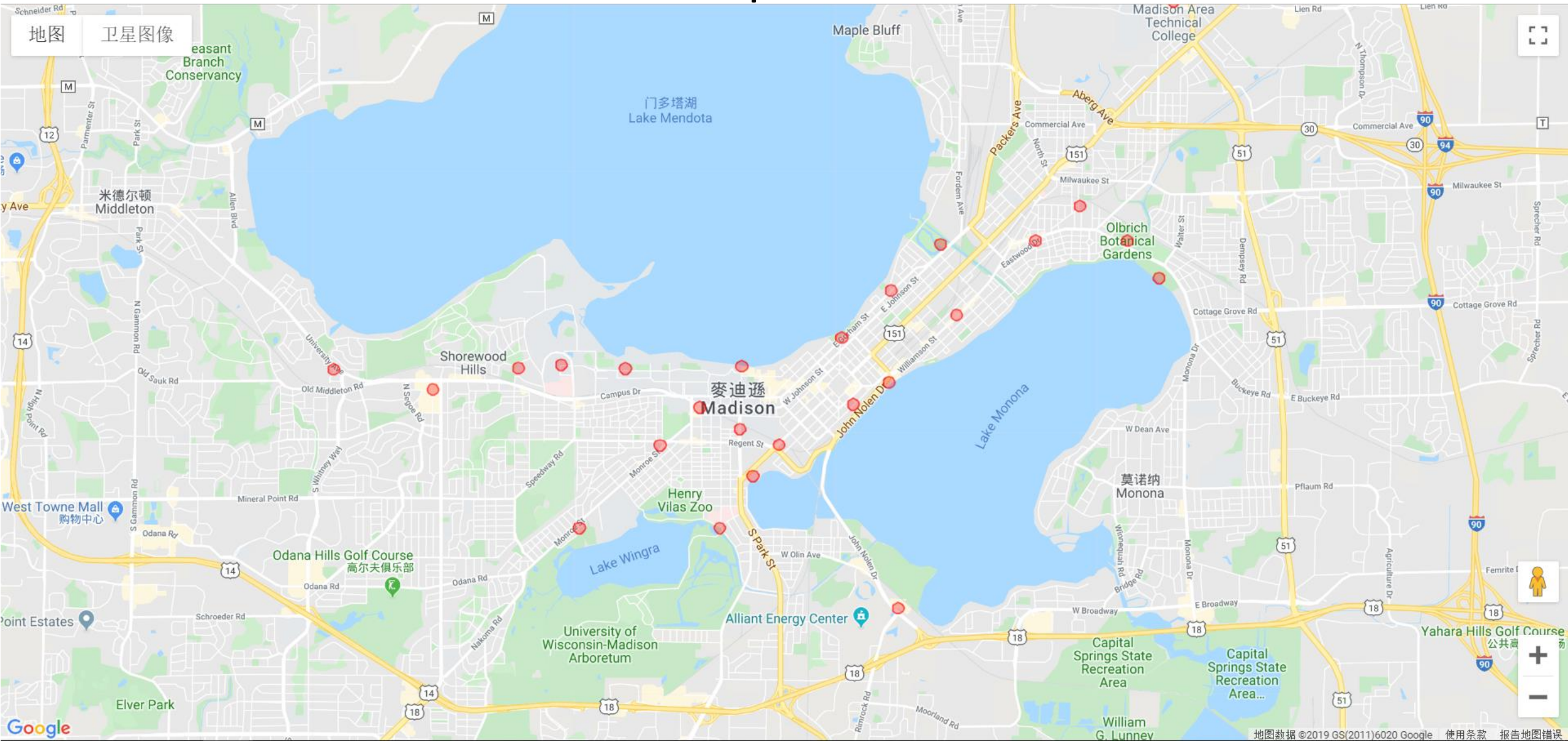
Set Packing Problem

- Since the BCycle has 46 sites in Dane County, we will 46 initial Lime scooter sites .
- And the optimal solution suggests the following **25 sites** and the coordinates for Lime scooter

```
Olbrich Gardens, 3330 Atwood Avenue (43.09247, -89.33570999999999)
2048 Eastwood Dr (43.092459999999996, -89.35115)
N Thornton at Tenney Park (43.092040000000004, -89.36715)
988 E Gorham Street (43.08634, -89.37546)
387 S Few Street (43.08334, -89.36443)
472 E Gorham Street (43.08056, -89.38374)
22 W Wilson Street (43.07237, -89.38179000000001)
John Noten Drive at Law Par k (43.07505, -89.3758)
150 North Shore Drive-Brittingham Park (43.06357, -89.39869)
677 W Washington Avenue (43.067370000000004, -89.39429)
N. Park Street at Spring Street (43.069309999999994, -89.40086)
Union South (43.071999999999996, -89.40764)
92 S Breese Terrace (43.06734, -89.41429000000001)
Vilas Park at Arboretum, 850 South Mills Street (43.05717, -89.40425)
Observatory Dr at NatatorilJm Gym (43.07677, -89.42011)
Observatory Dr at UW Hospital (43.077220000000004, -89.43088)
701 Knickerbocker Street (43.057179999999995, -89.42784)
1702 Rimrock Road (43.04732, -89.37423000000001)
726 N Midvale Blvd (43.07418, -89.45249)
UW Digestive Health Ctr, 750 University Row (43.07667, -89.46916999999999)
University Station Clin I c, 2880 University Avenue (43.07682, -89.43811)
699 North Park Street (43.07703, -89.40054)
Madison College Tr uax Campus, 1705 Wright Street (43.12185, -89.32791999999999)
Olbrich Biergarten, 3527 Atwood Ave (43.08787, -89.3304)
Goodman Community Ctr, 199 Waubesa St (43.09673, -89.34366999999999)


The maximum number of site is 25.0
```

Visualization for the optimal sites



Vehicles Routing Problem

- After obtaining the optimal sites for Lime scooter, we will build a model for Lime to solve the future vehicles routing problem when distributing the scooters to all the sites.
- We assume that Lime has **3 vehicles** to distribute the scooters and the scooter **depot is build at site 5**.
- The optimal solution suggests that the maximum of the route distance would be **15.49 km**.

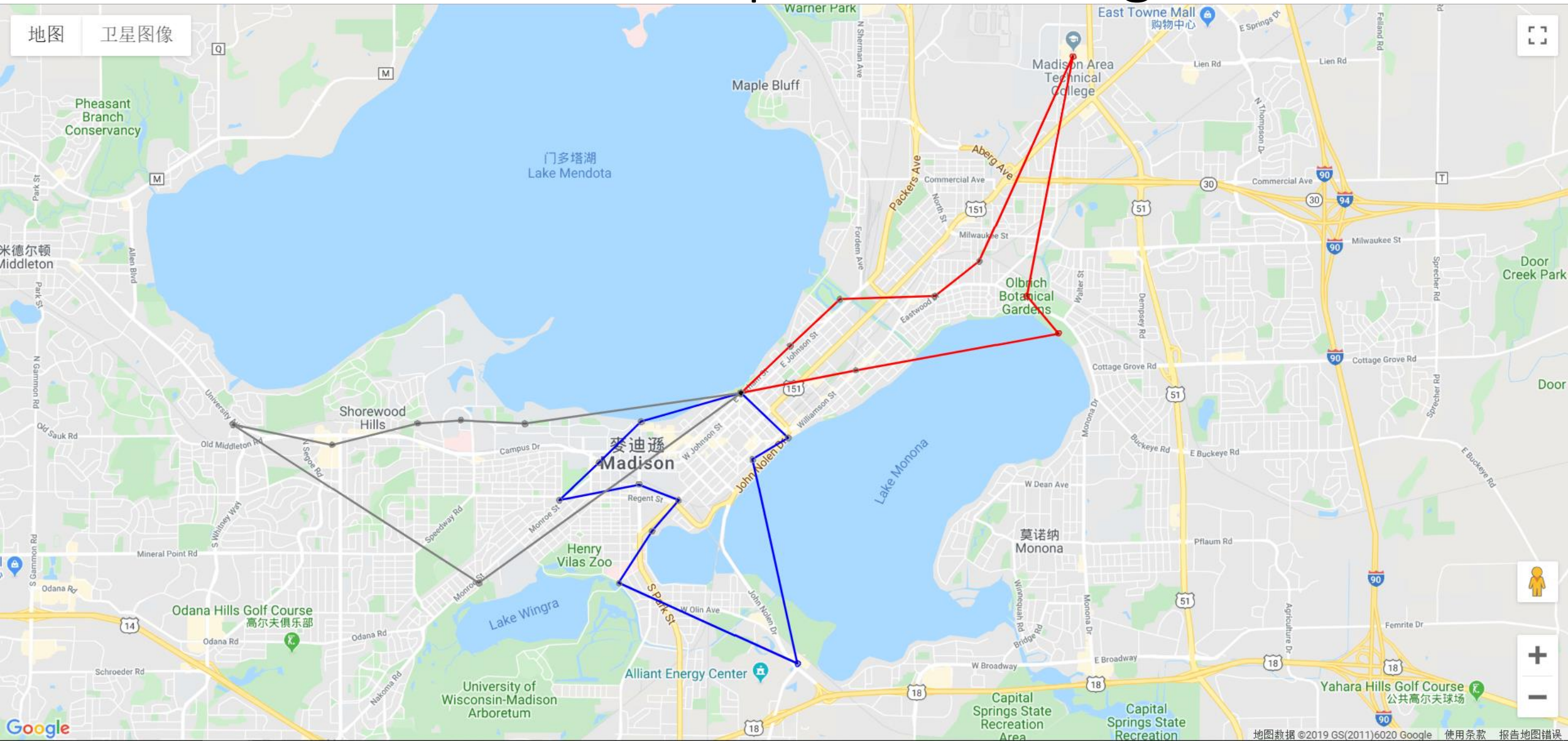
```
Route for vehicle 0:
 5 ->  7 ->  6 ->  17 ->  13 ->  8 ->  9 ->  10 ->  12 ->  11 ->  21 -> 5
Distance of the route: 13.05km

Route for vehicle 1:
 5 ->  4 ->  23 ->  0 ->  22 ->  24 ->  1 ->  2 ->  3 -> 5
Distance of the route: 15.41km

Route for vehicle 2:
 5 ->  16 ->  19 ->  18 ->  20 ->  15 ->  14 -> 5
Distance of the route: 15.49km

Maximum of the route distances: 15.49km
```

Visualization for the optimal routing



Conclusion

- Necessity for leverage Python:

The solver Pyomo and Google OR-Tools provide better optimization than Excel, and other packages in Python enable us to visualize the optimal solution easily.

- Project construction:

The files include a Excel that illustrate a toy instance of the set packing problem, and the optimization for Lime is processed on Python.