Drone Delivery Routing

An application of traveler's salesman problem

Problem at hand:

With the advancement of technology and robotics, Drone delivery has immense potential in the consumer economy. Companies such as Amazon and Facebook in the consumer sector, Pizza Hut and Dominos in the food sector are investing in such technology.

One of the main considerations in the implementation of drone delivery is the need to optimize the distances travelled. In order to address this, I have adapted the 'Travelers Salesman problem", into a "Vehicle Routing Problem". The objective of my "Vehicle Routing Problem" is to minimize the total distance travelled while addressing all the required deliveries and incorporating the realistic constraints of Drones (charge time, payload, flight time, etc).

For a company that is investing in Drones, the need to optimize its usage is vital, this makes my implementation and subsequent solution essential to the industry.

Constraints:

Total Flight Time: *42 Minutes (no-payload)*

22 Minutes (Fully Loaded)

Maximum Payload: 22 Lbs

Payload and Flight time are inversely Proportional to each other

Commonly found problem with drones for the use-case of delivery are that of flight time and payload capacity. For example, at once if the drone can carry 5 packages it must return to the base to get more packages, due to limit of payload capacity. Similarly, the flight time reduces and distance back to the base has to be kept in mind when traveling to a new destination, this can be increased by placing charge stations along the path which allow the drone to recharge and carry out the operation.

Assumptions:

For the sake of simplifying the model for an initial implementation we will be considering the following assumptions:

1. Charging time is not a variable, the objective is to minimize the total distance traveled
2. Full payload is 22 Pounds
3. Number of packages to be delivered = number of nodes in the graph
4. Flight time at full payload Is 22mins
5. Max Speed is 45mph

Using Austin street data and locations in and around Austin we show simulations of paths taken by the drone for delivering packages starting and ending at the Hub.

Python Packages/Modules used:

1. Networkx – To create the graph
2. Scipy and Numpy for maintaining distances and calculating nodes
3. Pandas – To import node data and details
4. Geopy – To calculate the distance from coordinates
    a. Geopy.distance.vincenty

Results:

The following results were obtained:

Model Graph:

To test the solution the algorithm was implemented on a model with five nodes/destinations Excluding the hub. Charging stations were arbitrarily placed at nodes which are just within the range of the drone, this is calculated using speed of the drone and distance of the node from the hub.

The model graph and solution can be seen below.

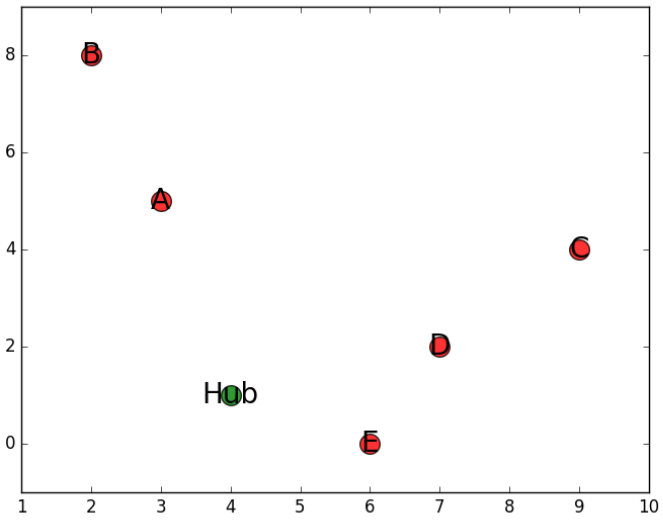

Figure 1 green Node = hub, Red nodes = destinations

After running the algorithm on the test case the following Path was suggested.

```
C:\Users\abhin\Anaconda2\python.exe Z:/Projects/Computational_Optimisation/Project-TSP/base.py
The Suggested Route is: ['Hub', 'D', 'Hub', 'C', 'D', 'B', 'Hub', 'A', 'C', 'Hub']

Process finished with exit code 0
```

Implementation on Austin Data:

As a test case, one of the implementations was based on the Austin City Data used in one of the course assignments. The image shown below is a map of a few locations in and around the UT Campus in Central Austin. The Node labeled Hub is where the deliveries will start from and end. Resource constraints here are as mentioned above and some relaxations are used.

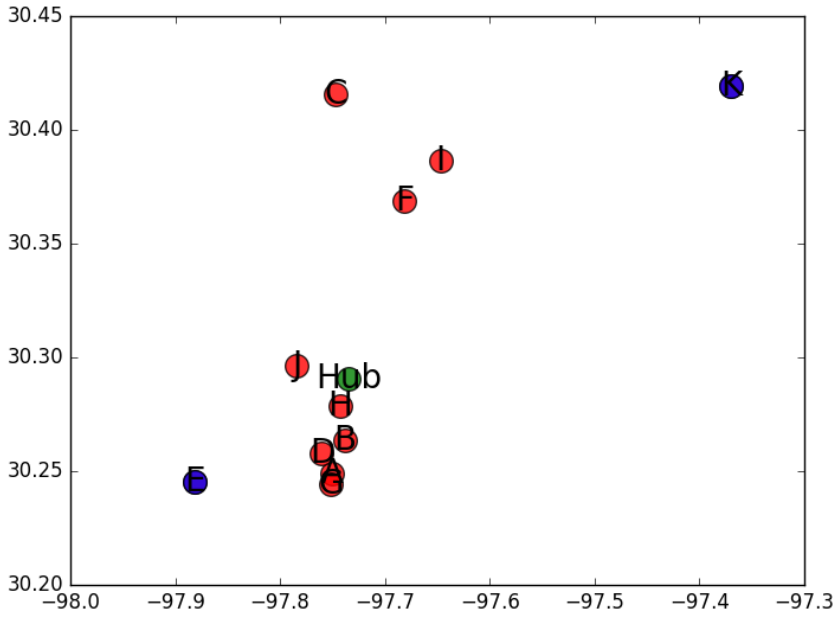

Figure 2 Green Node = Hub, Blue Nodes = Destinations with Charging Stations, Red nodes = Destinations

The solution to this model as shown is:

```
C:\Users\abhin\Anaconda2\python.exe Z:/Projects/Computational_Optimisation/Project-TSP/base.py
The Suggested Route is: ['Hub', 'A', 'Hub', 'Hub', 'A', 'E', 'Hub', 'Hub', 'Hub', 'Hub', 'A', 'D', 'E', 'F', 'Hub', 'Hub', 'Hub', 'Hub']

Process finished with exit code 0
```

As can be seen the model implemented is not ideal as the nodes are increased and need ot be adapted to take that into account.

Future Work on the model:

A lot of extensions and addition will be made to the algorithm such as:

1. Adding multiple delivery drones to the scenario
2. Adding payload capacity as a constraint where
3. Optimizing for large number of nodes