Sample Core Algorithm Overview

Stated Problem:

The purpose of this project is to develop an algorithm that will efficiently deliver packages for the Western Governor's University Parcel Service using Python. The goal for this service is to complete all deliveries in under 140 miles, using three trucks and two drivers. Certain constraints will apply to the packages, such as truck preferences, delayed package, wrong address information, deadlines, and packages that must be delivered together. As this is a variation of the Traveling Salesman Problem, I found it fitting to use the Greedy Algorithm, which works by determining the shortest path in between each package one at a time (hence Greedy). While this won't provide us with the optimal solution, it will be efficient and satisfactory. In the following paper we will explore how Greedy algorithm satisfies the stated problem, its efficiency, and how it compares to other algorithms of the same nature.

Algorithm Overview:

To implement the Greedy algorithm in this problem, we begin by providing the list of packages, associated trucks, and current location. The algorithm begins by going through the list of packages, and finding one that is lowest to our starting value of 50, and thus closest to our starting location at the Hub. Then the algorithm determines which truck the package is associated with, and adds it to a sorted list and sorted index list associated with the truck. The lowest value is then removed from the original list passed into the algorithm so that it skips over that in the following iterations. The new starting location is then set to this first package location, signifying the truck traveling. This algorithm is ran until no packages remain, the base case.

B1: Pseudocode

Pseudocode:

Input dist(list of packages), truck(list of trucks, loc(current location)

Space time complexity of O(1) - constant

Base case. If there are no objects on the list

Return the empty list and stop the loop

Space time complexity of O(1) - constant

Else if there are objects on the list

Set the lowest value to 50, distance of package from the starting location

Set the new location to 0

For index in the list,

If the current distance between starting location and package is less than the lowest value, the lowest value is set to that number.

O(n) Space Time Complexity

Second for loop,

For index in the list,

If the current distance between current location and package is the lowest value

If the associated truck = 1(first truck)

Index appended to first_sorted_truck (Value is appended to first truck list)

Index appended to first_sorted_index (Value is appended to first truck index list)

dist pop index (package removed from the input package list)

loc = new (current location becomes this package's location)

If the associated truck = 2(second truck)

Index appended to second_sorted_truck (Value is appended to first truck list)

Index appended to second_sorted_index (Value is appended to first truck index list)

dist pop index (package removed from the input package list)

loc = new (current location becomes this package's location)

If the associated truck = 3 (third truck)

Index appended to third_sorted_truck (Value is appended to first truck list)

Index appended to third_sorted_index (Value is appended to first truck index list)

dist pop index (package removed from the input package list)

loc = new (current location becomes this package's location)

O(N^2) Space time complexity, since it involves two nested loops, the second function for the associated trucks runs each time the first function runs for every package, n x n times.

B2

The application was written using Python 3.8 in PyCharm 2021.1.1(Community edition). The program was written on a Windows Surface Laptop running Windows 10, 64 bit operating system, with an Intel Core Processor.

B3*:*

Represented here is the space-time complexity of each major segment of the program and the entire program, using big-O notation.

Main.Py	**Space-time Complexity**	**Total**
Line 17	O(N)	
Line 25	O(N^2)	
Line 67	O(N)	
Line 115	O(1)	
		O(N^2)

hash_map.py	**Space-time Complexity**	**Total**
hash_key (line 14)	O(1)	
insert (line 19)	O(N)	
search (line 38)	O(N)	
update (line 47)	O(N)	
init (line 6)	O(1)	
		O(N)

distance.py	**Space-time Complexity**	**Total**
get_total_distance (line 12)	O(1)	
get_current_distance(line 21)	O(1)	
get_first_package_times (line 36)	O(N)	
get_second_package_times (line 49)	O(N)	
get_third_package_times (line 61)	O(N)	
get_addy (line 74)	O(1)	
first_sorted_index_get	O(1)	
first_sorted_truck_get	O(1)	
second_sorted_index_get	O(1)	
second_sorted_truck_get	O(1)	
third_sorted_index_get	O(1)	
third_sorted_truck_get	O(1)	
get_path	O(N^2)	
		O(N^2)

packages.py	**Space-time Complexity**	**Total**
line 41	O(N)	
line 48	O(N^2)	
line 62	O(1)	
line 67	O(N)	
line 80	O(N)	
line 87	O(N^2)	
line 99	O(1)	
line 103	O(N)	
line 116	O(N)	
line 123	O(N^2)	
line 135	O(1)	
line 140	O(N)	
total_distance (line 153)	O(1)	
		O(N^2)

ReadPackageCsv.py	**Space-time Complexity**	**Total**
line 17	O(N)	
get_hash_instance	O(1)	
get_first_truck_list	O(1)	
get_second_truck_list	O(1)	
get_third_truck_list	O(1)	
		O(N)

Total Program	**Calculation**	**Total**
DaryaKrutyevaC950WGU	O(N^2) + O(N) + O(N^2) + O(N^2) + O(N)	**O(N^2)**

B4:

While this application works efficiently with smaller data sets, it becomes slower with larger data sets. For an algorithm with O(N^2) space-time complexity, if you increase the n by a factor of z, the run time increase by z^2. So if the input is doubled, the run time is quadrupled. Of-course, this can be offset by having stronger hardware. Scaling this application is as simple as changing the CSV file to include additional packages, as well as their addresses and distances. Scaling in the sense of expanding the company is also fairly simple: since a lot of the functions are the same but adapted to use with different trucks, we would simply need to copy and paste them as well as adjust the application to include additional lists. No major changes to the code are ever needed.

B5:

This application is very maintainable, as it's intuitively split up into different files which represent different functionalities. For example, the hash_map file holds every method needed to interact with the hash map, and the Packages.py file handles the sorting of the packages. Each file is also broken down into different sections, usually by truck number. This application is very readable, allowing for any corrections, and has fairly few lines thus taking less time to get through. It's formatted and indented correctly per Python standards, making the structure consistent, and has is well documented, with meaningful comments for each method removing and room for ambiguity. The readability, maintainability, and size of the program, as well as the choice of a easy-to-understand and adaptable Greedy algorithm makes this application efficient as it's easy to add onto and expand it further.

B6:

A hash table was used for this application as it's a fast and efficient way to store and retrieve data. Per ZyBooks, its main advantage is that "searching (or inserting/removing) an item may require only O(1), in contrast to O(n) for searching a list or to O(log N) for a binary search. Its main disadvantage is collisions, with larger data sets it becomes more likely that an item being inserted into a table will end up in the same bucket as another item, but there are collision resolution techniques available such as chaining, to address that issue. This application also uses lists[4], which are mutable and can hold a variety of DataTypes. One con I found while using a list is that I cannot set the maximum length of a list, which could have been useful when appending the packages.

C1/C2: Present within application

D1:

This application uses a hash-table as the self-adjusting data structure to be used with the Greedy Algorithm. As mentioned in B6, this data structure was used as it's very fast and efficient and may only require an O(1) space-time complexity. It accounts for the data points being stores, as the Package_ID is an intuitive choice to use to create the key, and a list can be used to store the value.

G1.

```
Package ID: 1    Address: 195 W Oakland Ave Salt Lake City UT 84115   Truck status: Departed at 8:00:00   Delivery status: Delivered at 8:53:00
Package ID: 2    Address: 2530 S 500 E Salt Lake City UT 84106   Truck status: Departs at 9:05:00   Delivery status: At the Hub
Package ID: 3    Address: 233 Canyon Rd Salt Lake City UT 84103   Truck status: Departs at 9:05:00   Delivery status: At the Hub
Package ID: 4    Address: 380 W 2880 S Salt Lake City UT 84115   Truck status: Departs at 11:00:00   Delivery status: At the Hub
Package ID: 5    Address: 410 S State St Salt Lake City UT 84111   Truck status: Departs at 11:00:00   Delivery status: At the Hub
Package ID: 6    Address: 3060 Lester St West Valley City UT 84119   Truck status: Departs at 9:05:00   Delivery status: At the Hub
Package ID: 7    Address: 1330 2100 S Salt Lake City UT 84106   Truck status: Departs at 11:00:00   Delivery status: At the Hub
Package ID: 8    Address: 300 State St Salt Lake City UT 84103   Truck status: Departs at 9:05:00   Delivery status: At the Hub
Package ID: 9    Address: 410 S State St Salt Lake City UT 84111   Truck status: Departs at 11:00:00   Delivery status: At the Hub
Package ID: 10    Address: 600 E 900 South Salt Lake City UT 84105   Truck status: Departs at 11:00:00   Delivery status: At the Hub
Package ID: 11    Address: 2600 Taylorsville Blvd Salt Lake City UT 84118   Truck status: Departs at 9:05:00   Delivery status: At the Hub
Package ID: 12    Address: 3575 W Valley Central Station bus Loop West Valley City UT 84119   Truck status: Departs at 11:00:00   Delivery status:
Package ID: 13    Address: 2010 W 500 S Salt Lake City UT 84104   Truck status: Departed at 8:00:00   Delivery status: On the way
Package ID: 14    Address: 4300 S 1300 E Millcreek UT 84117   Truck status: Departed at 8:00:00   Delivery status: Delivered at 8:06:00
Package ID: 15    Address: 4580 S 2300 E Holladay UT 84117   Truck status: Departed at 8:00:00   Delivery status: Delivered at 8:13:00
Package ID: 16    Address: 4580 S 2300 E Holladay UT 84117   Truck status: Departed at 8:00:00   Delivery status: Delivered at 8:13:00
Package ID: 17    Address: 3148 S 1100 W Salt Lake City UT 84119   Truck status: Departs at 9:05:00   Delivery status: At the Hub
Package ID: 18    Address: 1488 4800 S Salt Lake City UT 84123   Truck status: Departs at 9:05:00   Delivery status: At the Hub
Package ID: 19    Address: 177 W Price Ave Salt Lake City UT 84115   Truck status: Departed at 8:00:00   Delivery status: On the way
Package ID: 20    Address: 3595 Main St Salt Lake City UT 84115   Truck status: Departed at 8:00:00   Delivery status: Delivered at 8:30:00
Package ID: 21    Address: 3595 Main St Salt Lake City UT 84115   Truck status: Departs at 11:00:00   Delivery status: At the Hub
Package ID: 22    Address: 6351 South 900 East Murray UT 84121   Truck status: Departs at 11:00:00   Delivery status: At the Hub
Package ID: 23    Address: 5100 South 2700 West Salt Lake City UT 84118   Truck status: Departs at 9:05:00   Delivery status: At the Hub
Package ID: 24    Address: 5025 State St Murray UT 84107   Truck status: Departs at 11:00:00   Delivery status: At the Hub
Package ID: 25    Address: 5383 S 900 East #104 Salt Lake City UT 84117   Truck status: Departs at 9:05:00   Delivery status: At the Hub
Package ID: 26    Address: 5383 S 900 East #104 Salt Lake City UT 84117   Truck status: Departs at 11:00:00   Delivery status: At the Hub
Package ID: 27    Address: 1060 Dalton Ave S Salt Lake City UT 84104   Truck status: Departs at 9:05:00   Delivery status: At the Hub
Package ID: 28    Address: 2835 Main St Salt Lake City UT 84115   Truck status: Departs at 9:05:00   Delivery status: At the Hub
Package ID: 29    Address: 1330 2100 S Salt Lake City UT 84106   Truck status: Departed at 8:00:00   Delivery status: Delivered at 8:44:00
Package ID: 30    Address: 300 State St Salt Lake City UT 84103   Truck status: Departed at 8:00:00   Delivery status: On the way
Package ID: 31    Address: 3365 S 900 W Salt Lake City UT 84119   Truck status: Departed at 8:00:00   Delivery status: On the way
Package ID: 32    Address: 3365 S 900 W Salt Lake City UT 84119   Truck status: Departs at 9:05:00   Delivery status: At the Hub
Package ID: 33    Address: 2530 S 500 E Salt Lake City UT 84106   Truck status: Departs at 11:00:00   Delivery status: At the Hub
Package ID: 34    Address: 4580 S 2300 E Holladay UT 84117   Truck status: Departed at 8:00:00   Delivery status: Delivered at 8:13:00
Package ID: 35    Address: 1060 Dalton Ave S Salt Lake City UT 84104   Truck status: Departs at 11:00:00   Delivery status: At the Hub
Package ID: 36    Address: 2300 Parkway Blvd West Valley City UT 84119   Truck status: Departs at 9:05:00   Delivery status: At the Hub
Package ID: 37    Address: 410 S State St Salt Lake City UT 84111   Truck status: Departed at 8:00:00   Delivery status: On the way
```

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Package ID: 37    Address: 410 S State St Salt Lake City UT 84111   Truck status: Departed at 8:00:00   Delivery status: On the way
Package ID: 38    Address: 410 S State St Salt Lake City UT 84111   Truck status: Departs at 9:05:00   Delivery status: At the Hub
Package ID: 39    Address: 2010 W 500 S Salt Lake City UT 84104   Truck status: Departs at 11:00:00   Delivery status: At the Hub
Package ID: 40    Address: 380 W 2880 S Salt Lake City UT 84115   Truck status: Departed at 8:00:00   Delivery status: Delivered at 8:57:00
```

G2:

```
Enter a time to check, in HH:MM:SS format: 10:00:00
Package ID: 1    Address: 195 W Oakland Ave Salt Lake City UT 84115   Truck status: Departed at 8:00:00   Delivery status: Delivered at 8:53:00
Package ID: 2    Address: 2530 S 500 E Salt Lake City UT 84106   Truck status: Departed at 9:05:00   Delivery status: Delivered at 9:29:00
Package ID: 3    Address: 233 Canyon Rd Salt Lake City UT 84103   Truck status: Departed at 9:05:00   Delivery status: On the way
Package ID: 4    Address: 380 W 2880 S Salt Lake City UT 84115   Truck status: Departs at 11:00:00   Delivery status: At the Hub
Package ID: 5    Address: 410 S State St Salt Lake City UT 84111   Truck status: Departs at 11:00:00   Delivery status: At the Hub
Package ID: 6    Address: 3060 Lester St West Valley City UT 84119   Truck status: Departed at 9:05:00   Delivery status: Delivered at 9:49:00
Package ID: 7    Address: 1330 2100 S Salt Lake City UT 84106   Truck status: Departs at 11:00:00   Delivery status: At the Hub
Package ID: 8    Address: 300 State St Salt Lake City UT 84103   Truck status: Departed at 9:05:00   Delivery status: On the way
Package ID: 9    Address: 410 S State St Salt Lake City UT 84111   Truck status: Departs at 11:00:00   Delivery status: At the Hub
Package ID: 10    Address: 600 E 900 South Salt Lake City UT 84105   Truck status: Departs at 11:00:00   Delivery status: At the Hub
Package ID: 11    Address: 2600 Taylorsville Blvd Salt Lake City UT 84118   Truck status: Departed at 9:05:00   Delivery status: On the way
Package ID: 12    Address: 3575 W Valley Central Station bus Loop West Valley City UT 84119   Truck status: Departs at 11:00:00   Delivery status: At the Hub
Package ID: 13    Address: 2010 W 500 S Salt Lake City UT 84104   Truck status: Departed at 8:00:00   Delivery status: Delivered at 9:31:00
Package ID: 14    Address: 4300 S 1300 E Millcreek UT 84117   Truck status: Departed at 8:00:00   Delivery status: Delivered at 8:06:00
Package ID: 15    Address: 4580 S 2300 E Holladay UT 84117   Truck status: Departed at 8:00:00   Delivery status: Delivered at 8:13:00
Package ID: 16    Address: 4580 S 2300 E Holladay UT 84117   Truck status: Departed at 8:00:00   Delivery status: Delivered at 8:13:00
Package ID: 17    Address: 3148 S 1100 W Salt Lake City UT 84119   Truck status: Departed at 9:05:00   Delivery status: Delivered at 9:42:00
Package ID: 18    Address: 1488 4800 S Salt Lake City UT 84123   Truck status: Departed at 9:05:00   Delivery status: On the way
Package ID: 19    Address: 177 W Price Ave Salt Lake City UT 84115   Truck status: Departed at 8:00:00   Delivery status: Delivered at 9:03:00
Package ID: 20    Address: 3595 Main St Salt Lake City UT 84115   Truck status: Departed at 8:00:00   Delivery status: Delivered at 8:30:00
Package ID: 21    Address: 3595 Main St Salt Lake City UT 84115   Truck status: Departs at 11:00:00   Delivery status: At the Hub
Package ID: 22    Address: 6351 South 900 East Murray UT 84121   Truck status: Departs at 11:00:00   Delivery status: At the Hub
Package ID: 23    Address: 5100 South 2700 West Salt Lake City UT 84118   Truck status: Departed at 9:05:00   Delivery status: On the way
Package ID: 24    Address: 5025 State St Murray UT 84107   Truck status: Departs at 11:00:00   Delivery status: At the Hub
Package ID: 25    Address: 5383 S 900 East #104 Salt Lake City UT 84117   Truck status: Departed at 9:05:00   Delivery status: Delivered at 9:13:00
Package ID: 26    Address: 5383 S 900 East #104 Salt Lake City UT 84117   Truck status: Departs at 11:00:00   Delivery status: At the Hub
Package ID: 27    Address: 1060 Dalton Ave S Salt Lake City UT 84104   Truck status: Departed at 9:05:00   Delivery status: On the way
Package ID: 28    Address: 2835 Main St Salt Lake City UT 84115   Truck status: Departed at 9:05:00   Delivery status: Delivered at 9:33:00
Package ID: 29    Address: 1330 2100 S Salt Lake City UT 84106   Truck status: Departed at 8:00:00   Delivery status: Delivered at 8:44:00
Package ID: 30    Address: 300 State St Salt Lake City UT 84103   Truck status: Departed at 8:00:00   Delivery status: Delivered at 9:45:00
Package ID: 31    Address: 3365 S 900 W Salt Lake City UT 84119   Truck status: Departed at 8:00:00   Delivery status: Delivered at 9:12:00
Package ID: 32    Address: 3365 S 900 W Salt Lake City UT 84119   Truck status: Departed at 9:05:00   Delivery status: Delivered at 9:44:00
Package ID: 33    Address: 2530 S 500 E Salt Lake City UT 84106   Truck status: Departs at 11:00:00   Delivery status: At the Hub
Package ID: 34    Address: 4580 S 2300 E Holladay UT 84117   Truck status: Departed at 8:00:00   Delivery status: Delivered at 8:13:00
```

```
Package ID: 35    Address: 1060 Dalton Ave S Salt Lake City UT 84104   Truck status: Departs at 11:00:00   Delivery status: At the Hub
Package ID: 36    Address: 2300 Parkway Blvd West Valley City UT 84119   Truck status: Departed at 9:05:00   Delivery status: Delivered at 9:
Package ID: 37    Address: 410 S State St Salt Lake City UT 84111   Truck status: Departed at 8:00:00   Delivery status: Delivered at 9:42:00
Package ID: 38    Address: 410 S State St Salt Lake City UT 84111   Truck status: Departed at 9:05:00   Delivery status: On the way
Package ID: 39    Address: 2010 W 500 S Salt Lake City UT 84104   Truck status: Departs at 11:00:00   Delivery status: At the Hub
Package ID: 40    Address: 380 W 2880 S Salt Lake City UT 84115   Truck status: Departed at 8:00:00   Delivery status: Delivered at 8:57:00
```

G3:

```
Package ID: 1    Address: 195 W Oakland Ave Salt Lake City UT 84115   Truck status: Departed at 8:00:00   Delivery status: Delivered at 8:53:00
Package ID: 2    Address: 2530 S 500 E Salt Lake City UT 84106   Truck status: Departed at 9:05:00   Delivery status: Delivered at 9:29:00
Package ID: 3    Address: 233 Canyon Rd Salt Lake City UT 84103   Truck status: Departed at 9:05:00   Delivery status: Delivered at 10:19:00
Package ID: 4    Address: 380 W 2880 S Salt Lake City UT 84115   Truck status: Departed at 11:00:00   Delivery status: Delivered at 11:12:00
Package ID: 5    Address: 410 S State St Salt Lake City UT 84111   Truck status: Departed at 11:00:00   Delivery status: Delivered at 11:38:00
Package ID: 6    Address: 3060 Lester St West Valley City UT 84119   Truck status: Departed at 9:05:00   Delivery status: Delivered at 9:49:00
Package ID: 7    Address: 1330 2100 S Salt Lake City UT 84106   Truck status: Departed at 11:00:00   Delivery status: Delivered at 11:23:00
Package ID: 8    Address: 300 State St Salt Lake City UT 84103   Truck status: Departed at 9:05:00   Delivery status: Delivered at 10:25:00
Package ID: 9    Address: 410 S State St Salt Lake City UT 84111   Truck status: Departed at 11:00:00   Delivery status: Delivered at 11:38:00
Package ID: 10    Address: 600 E 900 South Salt Lake City UT 84105   Truck status: Departed at 11:00:00   Delivery status: Delivered at 11:32:00
Package ID: 11    Address: 2600 Taylorsville Blvd Salt Lake City UT 84118   Truck status: Departed at 9:05:00   Delivery status: Delivered at 11:05:00
Package ID: 12    Address: 3575 W Valley Central Station bus Loop West Valley City UT 84119   Truck status: Departed at 11:00:00   Delivery status: On the way
Package ID: 13    Address: 2010 W 500 S Salt Lake City UT 84104   Truck status: Departed at 8:00:00   Delivery status: Delivered at 9:31:00
Package ID: 14    Address: 4300 S 1300 E Millcreek UT 84117   Truck status: Departed at 8:00:00   Delivery status: Delivered at 8:06:00
Package ID: 15    Address: 4580 S 2300 E Holladay UT 84117   Truck status: Departed at 8:00:00   Delivery status: Delivered at 8:13:00
Package ID: 16    Address: 4580 S 2300 E Holladay UT 84117   Truck status: Departed at 8:00:00   Delivery status: Delivered at 8:13:00
Package ID: 17    Address: 3148 S 1100 W Salt Lake City UT 84119   Truck status: Departed at 9:05:00   Delivery status: Delivered at 9:42:00
Package ID: 18    Address: 1488 4800 S Salt Lake City UT 84123   Truck status: Departed at 9:05:00   Delivery status: Delivered at 11:02:00
Package ID: 19    Address: 177 W Price Ave Salt Lake City UT 84115   Truck status: Departed at 8:00:00   Delivery status: Delivered at 9:03:00
Package ID: 20    Address: 3595 Main St Salt Lake City UT 84115   Truck status: Departed at 8:00:00   Delivery status: Delivered at 8:30:00
Package ID: 21    Address: 3595 Main St Salt Lake City UT 84115   Truck status: Departed at 11:00:00   Delivery status: Delivered at 11:07:00
Package ID: 22    Address: 6351 South 900 East Murray UT 84121   Truck status: Departed at 11:00:00   Delivery status: On the way
Package ID: 23    Address: 5100 South 2700 West Salt Lake City UT 84118   Truck status: Departed at 9:05:00   Delivery status: Delivered at 11:04:00
Package ID: 24    Address: 5025 State St Murray UT 84107   Truck status: Departed at 11:00:00   Delivery status: On the way
Package ID: 25    Address: 5383 S 900 East #104 Salt Lake City UT 84117   Truck status: Departed at 9:05:00   Delivery status: Delivered at 9:13:00
Package ID: 26    Address: 5383 S 900 East #104 Salt Lake City UT 84117   Truck status: Departed at 11:00:00   Delivery status: On the way
Package ID: 27    Address: 1060 Dalton Ave S Salt Lake City UT 84104   Truck status: Departed at 9:05:00   Delivery status: Delivered at 10:03:00
Package ID: 28    Address: 2835 Main St Salt Lake City UT 84115   Truck status: Departed at 9:05:00   Delivery status: Delivered at 9:33:00
Package ID: 29    Address: 1330 2100 S Salt Lake City UT 84106   Truck status: Departed at 8:00:00   Delivery status: Delivered at 8:44:00
Package ID: 30    Address: 300 State St Salt Lake City UT 84103   Truck status: Departed at 8:00:00   Delivery status: Delivered at 9:45:00
Package ID: 31    Address: 3365 S 900 W Salt Lake City UT 84119   Truck status: Departed at 8:00:00   Delivery status: Delivered at 9:12:00
Package ID: 32    Address: 3365 S 900 W Salt Lake City UT 84119   Truck status: Departed at 9:05:00   Delivery status: Delivered at 9:44:00
Package ID: 33    Address: 2530 S 500 E Salt Lake City UT 84106   Truck status: Departed at 11:00:00   Delivery status: Delivered at 11:18:00
Package ID: 34    Address: 4580 S 2300 E Holladay UT 84117   Truck status: Departed at 8:00:00   Delivery status: Delivered at 8:13:00
Package ID: 35    Address: 1060 Dalton Ave S Salt Lake City UT 84104   Truck status: Departed at 11:00:00   Delivery status: Delivered at 11:54:00
```

```
Package ID: 36    Address: 2300 Parkway Blvd West Valley City UT 84119   Truck status: Departed at 9:05:00   Delivery sta
Package ID: 37    Address: 410 S State St Salt Lake City UT 84111   Truck status: Departed at 8:00:00   Delivery status:
Package ID: 38    Address: 410 S State St Salt Lake City UT 84111   Truck status: Departed at 9:05:00   Delivery status:
Package ID: 39    Address: 2010 W 500 S Salt Lake City UT 84104   Truck status: Departed at 11:00:00   Delivery status: D
Package ID: 40    Address: 380 W 2880 S Salt Lake City UT 84115   Truck status: Departed at 8:00:00   Delivery status: De
```

H.

```
C:\Users\Darya\PycharmProjects\DaryaKrutyeva\venv\Scripts\python.exe C:/Users/Darya/PycharmProjects/DaryaKrutyeva/main.py
Thanks for using the Western Governors University Parcel Service
Please select from the following menu options:
1. Track all packages
2. Track a specific package
3. Display total distance traveled
4. Quit
Input number choice here: 3
Trucks completed deliveries with a total of 103.8 miles

Process finished with exit code 0
```

I.

1. Advantages:

- Breaks the problem down into smaller problems, making it easier to understand.

- Always takes the best available choice

2. Meets requirements:

This is shown in H, by completing the route in under 140 miles. The solution also meets requirements by using all the constraints for loading the packages, as well as using only two drivers and 3 trucks.

Here is evidence of functionality for F: look-up function.

```
C:\Users\Darya\PycharmProjects\DaryaKrutyeva\venv\Scripts\python.exe C:/Users/Darya/PycharmProjects/DaryaKrutyeva/main.py
Thanks for using the Western Governors University Parcel Service
Please select from the following menu options:
1. Track all packages
2. Track a specific package
3. Display total distance traveled
4. Quit
Input number choice here: 2
Enter package ID: 1
Enter a time in HH:MM:SS format: 09:00:00
Package ID: 1    Address: 195 W Oakland Ave Salt Lake City UT 84115   Deadline: 10:30:00  Weight: 21   Truck status: Departed at 8:00:00   Delivery status: Delivered at 8:53:00
Enter package ID:
```

3/3A: One alternative algorithm I could have used is the Floyd Warshall Algorithm, it determines the shortest path for graphs. It computes the shortest distance between every pair

of vertices in the graph. The advantage of this one is that it will tell you the optimal shortest route for all the packages instead of calculating it one package at a time as is with Greedy[2]. Another algorithm I could have used is the Brute Force algorithm which would calculate the total distance for every route and the select the shortest one. However this algorithm is usually less efficient. [3]

J. If I were to do this project differently, I would implement a second algorithm that would load the packages onto the truck instead of doing it by hand. This would improve this application if it were scaled up to include thousands of packages.

K1.

- **a.** The time needed to complete the look up function is directly proportional by the number of packages, as it holds a linear time complexity of O(N). The more packages, the proportionally longer it takes to look up on a 1 to 1 scale.
- **b.** The space usage of the structure is O(N) which is linear. The more packages there are, a proportional amount of space will be used, on a 1-1 scale.
- **c.** The number of trucks or cities would not affect the look-up time and space usage of the structure. Only changing the number of packages to be inserted would change the look up time, as lists are used to store individual truck's packages, and the cities would affect distances which are also stored on lists.

K2. Instead of a hash-table, I could have used a binary search tree. The main difference is that a binary search tree stores ordered data whereas a hash-table does not. This could have been useful in storing the packages once they've already been optimally sorted by the algorithm. However, a BST is generally slower than a hash-table. I could have also used a graph, which would have been a useful way to store the addresses with the package information and then apply an algorithm such as Dijkstra's shortest path. This would have been very intuitive given that we are working with addresses and distances, and a graph could provide us with a map. It is very useful in networking problems

Sources:

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