Project Summary

Problem Statement

The Western Governors University Parcel Service (WGUPS) needs to determine an efficient route and delivery distribution for their Daily Local Deliveries (DLD) because packages are not currently being consistently delivered by their promised deadline. The Salt Lake City DLD route has three trucks, two drivers, and an average of 40 packages to deliver each day. Each package has specific criteria and delivery requirements.

Solution

In this program, we use Greedy Algorithm to design the route for the trucks. Based on each node, we find the local optimal vertex for the shortest route.

This program breaks down the multiple components: Database, Distance Matrix, Path Algorithm, Hub, and Truck. Everything is connected using a Global file. The database is using Hash Table as a data structure.

Pseudocode Simplify Logic Overview:

```
#########################################################

Initialize Global Element
Import Global Database
Create Trucks
Load Truck()
     Distribute Package to Truck from Hub(Read Global Database)
Get Route(Trucks)
     Design Path Base on What's in Truck(Read Distance Matrix)
Depart(Time)
     Record Each Nodes Time Base on Distance & MPH(Read Distance
Matrix)

Initiate Interface Screen
       Main Screen
          1. All Package Screen(Time, Read Global Database)
          2. ID Screen(Time, Read Global Database)
          3. Total Mileage Screen(Read Truck from Global)

#########################################################
```

The Space-Time Complexity:

Create Database( ) : O(n) , *where n is the number of packages.*

We loop through all packages and put each bin in the hash table.

Load Truck( ) : O(n) , *where n is the number of packages.*

The 1st loop goes through the special note, 2nd loop puts the remainder to trucks, both work in parallel.

Read Data( ) : O(n) , *where n is the number of packages.*

The get data is to read data from the database since the database is designed using a hash table, the complexity depends on the number of bins, in this case, we use 10 bins, which has a time complexity constant of 1/4 but ignore the constant here. However, you can use n amount it, it will just become a lookup table.

Get Delivery Nodes( ) : $O(n^2)$, *where n is the number of packages.*

This function is to find the match ID to the match nodes numbers, to check which node is in the truck. Essentially this function is calling previous Read Data( ) n times.

Get Route Path( ) : $O(n^2)$, *where n is the vertices between a list of delivery nodes in each truck*.

Since the Greedy Algorithm is used, for each number of nodes and there are vertices between all nodes. We have to look at each n-1 vertex to find the next shortest path.

Render Time( ) : O(n) , *where n is the numbers of packages.*

We loop through all packages from the original database and duplicate elements by changing only status based on the user setting of the time.

Overall it seems like the program is $O(n^2)$, since the Get Route Path( ) & Get Delivery Nodes( ) is dominating the rest. In reality, in this program Get Route Path( ) does depend on Get Delivery Nodes( ) first, before getting the route for those nodes since they are not nested together, they are just working in parallel in $O(n^2)$, so the time complexity is still $O(n^2)$.

Scalability and Adaptability:

As the number of packages grows, to not increase the computation time, we will increase the number of bins in our hash table, and the computation time will dramatically decrease. Also the Greedy Algorithm, we are using only looks into 1 layer in-depth for local optimal, therefore the computation will increase exponentially like O(n!) or $O(2^n)$, it will keep the entire program running under in $O(n^2)$.

Maintain Data Structure

Since the mileage requirement is not very tight, this program is designed to less computation instead of the most optimal. The software is also easy to maintain because it keeps in mind future changes of decisions, the algorithm, location matrix, and the interface section of the software are complete separate by files and by class. It will be easy to implement a new algorithm strategy, since rewriting the code are not necessary.

The hash table on which we store the data is very flexible to scale, since you can increase the number of bins, which increase memory and decreases computation time, or you can decrease the number of bins which decreases the memory and increases computation time.

The hash table is stored by specifying the bin size. Each data have a unique key such as Package_ID in this case. We first Hash the Package_ID, then we use the Total_Bin mod Hash # = Bin_Number

To get the data, we do the same thing to get the Bin, and loop through each element in the Bin.

However, a hash table can also become very inefficient when the element is not distributed evenly, which is also known as a hash collision. When too many hash collision occurs, the benefit of the algorithm will decade.

Program Interface

Screenshot 9:00 am:

```
C:\Users\Louis\PycharmProjects\C950_Projectv3\venv\Scripts\python.exe C:/Users/Louis/PycharmProjects/C950_Projectv3/main.py
Truck 1 depart at 08:00:00
Truck 1 is back at 10:24:20
Truck 2 depart at 08:00:00
Truck 2 is back at 10:37:00
Truck 3 depart at 10:24:20
Truck 3 is back at 11:29:40

--- THE MAIN MENU ---
 Enter A Number:    1.Get_All_Packages  2.Get_Package_By_ID     3.Get_Total_Mileage
1
Enter the Time(HH:MM:SS):
9:00:00
ID:  1   Address:  195 W Oakland Ave Salt Lake City UT 84115   Deadline:  10:30 AM   Weight:  21   Note:     Status & Time:  Delivered @ 08:38:40
ID:  2   Address:  2530 S 500 E Salt Lake City UT 84106   Deadline:  EOD   Weight:  44   Note:     Status & Time:  Delivered @ 08:43:40
ID:  3   Address:  233 Canyon Rd Salt Lake City UT 84103   Deadline:  EOD   Weight:  2   Note:  Can only be on truck 2   Status & Time:  Enroute @ 08:00:00
ID:  4   Address:  380 W 2880 S Salt Lake City UT 84115   Deadline:  EOD   Weight:  4   Note:     Status & Time:  Delivered @ 08:35:00
ID:  5   Address:  410 S State St Salt Lake City UT 84111   Deadline:  EOD   Weight:  5   Note:     Status & Time:  Enroute @ 08:00:00
ID:  6   Address:  3060 Lester St West Valley City UT 84119   Deadline:  10:30 AM   Weight:  88   Note:  Delayed on flight---will not arrive to depot until 9:05 am   Status & Time:  Delayed Arriving Hub @ 9:05:00
ID:  7   Address:  1330 2100 S Salt Lake City UT 84106   Deadline:  EOD   Weight:  8   Note:     Status & Time:  Delivered @ 08:49:00
ID:  8   Address:  300 State St Salt Lake City UT 84103   Deadline:  EOD   Weight:  9   Note:     Status & Time:  Enroute @ 08:00:00
ID:  9   Address:  410 S State St Salt Lake City UT 84111   Deadline:  EOD   Weight:  2   Note:  Wrong address listed   Status & Time:  Enroute @ 08:00:00
ID:  10   Address:  600 E 900 South Salt Lake City UT 84105   Deadline:  EOD   Weight:  1   Note:     Status & Time:  Delivered @ 08:58:20
ID:  11   Address:  2600 Taylorsville Blvd Salt Lake City UT 84118   Deadline:  EOD   Weight:  1   Note:     Status & Time:  Enroute @ 08:00:00
ID:  12   Address:  3575 W Valley Central Station bus Loop West Valley City UT 84119   Deadline:  EOD   Weight:  1   Note:     Status & Time:  Enroute @ 08:00:00
ID:  13   Address:  2010 W 500 S Salt Lake City UT 84104   Deadline:  10:30 AM   Weight:  2   Note:     Status & Time:  Enroute @ 08:00:00
ID:  14   Address:  4300 S 1300 E Millcreek UT 84117   Deadline:  10:30 AM   Weight:  88   Note:  Must be delivered with 15, 19   Status & Time:  Delivered @ 08:06:20
ID:  15   Address:  4580 S 2300 E Holladay UT 84117   Deadline:  9:00 AM   Weight:  4   Note:     Status & Time:  Delivered @ 08:13:00
ID:  16   Address:  4580 S 2300 E Holladay UT 84117   Deadline:  10:30 AM   Weight:  88   Note:  Must be delivered with 13, 19   Status & Time:  Delivered @ 08:13:00
ID:  17   Address:  3148 S 1100 W Salt Lake City UT 84119   Deadline:  EOD   Weight:  2   Note:     Status & Time:  Enroute @ 08:00:00
ID:  18   Address:  1488 4800 S Salt Lake City UT 84123   Deadline:  EOD   Weight:  6   Note:  Can only be on truck 2   Status & Time:  Enroute @ 08:00:00
ID:  19   Address:  177 W Price Ave Salt Lake City UT 84115   Deadline:  EOD   Weight:  37   Note:     Status & Time:  Delivered @ 08:08:20
ID:  20   Address:  3595 Main St Salt Lake City UT 84115   Deadline:  10:30 AM   Weight:  37   Note:  Must be delivered with 13, 15   Status & Time:  Delivered @ 08:29:40
ID:  21   Address:  3595 Main St Salt Lake City UT 84115   Deadline:  EOD   Weight:  3   Note:     Status & Time:  Delivered @ 08:06:40
ID:  22   Address:  6351 South 900 East Murray UT 84121   Deadline:  EOD   Weight:  2   Note:     Status & Time:  Delivered @ 08:26:40
ID:  23   Address:  5100 South 2700 West Salt Lake City UT 84118   Deadline:  EOD   Weight:  5   Note:     Status & Time:  Enroute @ 08:00:00
ID:  24   Address:  5025 State St Murray UT 84107   Deadline:  EOD   Weight:  7   Note:     Status & Time:  Delivered @ 08:16:40
ID:  25   Address:  5383 South 900 East #104 Salt Lake City UT 84117   Deadline:  10:30 AM   Weight:  7   Note:  Delayed on flight---will not arrive to depot until 9:05 am   Status & Time:  Delayed Arriving Hub @ 9:05:00
ID:  26   Address:  5383 South 900 East #104 Salt Lake City UT 84117   Deadline:  EOD   Weight:  25   Note:     Status & Time:  Delivered @ 08:22:20
```

```
ID:  27   Address:  1060 Dalton Ave S Salt Lake City UT 84104   Deadline:  EOD   Weight:  5   Note:     Status & Time:  Enroute @ 08:00:00
ID:  28   Address:  2835 Main St Salt Lake City UT 84115   Deadline:  EOD   Weight:  7   Note:  Delayed on flight---will not arrive to depot until 9:05 am   Status & Time:  Delayed Arriving Hub @ 9:05:00
ID:  29   Address:  1330 2100 S Salt Lake City UT 84106   Deadline:  10:30 AM   Weight:  2   Note:     Status & Time:  Delivered @ 08:59:00
ID:  30   Address:  300 State St Salt Lake City UT 84103   Deadline:  10:30 AM   Weight:  1   Note:     Status & Time:  Enroute @ 08:00:00
ID:  31   Address:  3365 S 900 W Salt Lake City UT 84119   Deadline:  10:30 AM   Weight:  1   Note:     Status & Time:  Enroute @ 08:00:00
ID:  32   Address:  3365 S 900 W Salt Lake City UT 84119   Deadline:  EOD   Weight:  1   Note:  Delayed on flight---will not arrive to depot until 9:05 am   Status & Time:  Delayed Arriving Hub @ 9:05:00
ID:  33   Address:  2530 S 500 E Salt Lake City UT 84106   Deadline:  EOD   Weight:  1   Note:     Status & Time:  Enroute @ 08:00:00
ID:  34   Address:  4580 S 2300 E Holladay UT 84117   Deadline:  10:30 AM   Weight:  2   Note:     Status & Time:  Delivered @ 08:42:20
ID:  35   Address:  1060 Dalton Ave S Salt Lake City UT 84104   Deadline:  EOD   Weight:  88   Note:     Status & Time:  Hub @ 08:00:00
ID:  36   Address:  2300 Parkway Blvd West Valley City UT 84119   Deadline:  EOD   Weight:  88   Note:  Can only be on truck 2   Status & Time:  Enroute @ 08:00:00
ID:  37   Address:  410 S State St Salt Lake City UT 84111   Deadline:  10:30 AM   Weight:  2   Note:     Status & Time:  Hub @ 08:00:00
ID:  38   Address:  410 S State St Salt Lake City UT 84111   Deadline:  EOD   Weight:  9   Note:  Can only be on truck 2   Status & Time:  Enroute @ 08:00:00
ID:  39   Address:  2010 W 500 S Salt Lake City UT 84104   Deadline:  EOD   Weight:  9   Note:     Status & Time:  Hub @ 08:00:00
ID:  40   Address:  380 W 2880 S Salt Lake City UT 84115   Deadline:  10:30 AM   Weight:  45   Note:     Status & Time:  Hub @ 08:00:00
```

Screenshot 10:00 am:

```
C:\Users\Louis\PycharmProjects\C950_Projectv3\venv\Scripts\python.exe C:/Users/Louis/PycharmProjects/C950_Projectv3/main.py
Truck 1 depart at 08:00:00
Truck 1 is back at 10:24:20
Truck 2 depart at 08:00:00
Truck 2 is back at 10:37:00
Truck 3 depart at 10:24:20
Truck 3 is back at 11:29:40

--- THE MAIN MENU ---
 Enter A Number:    1.Get_All_Packages  2.Get_Package_By_ID     3.Get_Total_Mileage
1
Enter the Time(HH:MM:SS):
10:00:00
ID:  1   Address:  195 W Oakland Ave Salt Lake City UT 84115   Deadline:  10:30 AM   Weight:  21   Note:     Status & Time:  Delivered @ 08:38:40
ID:  2   Address:  2530 S 500 E Salt Lake City UT 84106   Deadline:  EOD   Weight:  44   Note:     Status & Time:  Delivered @ 08:43:40
ID:  3   Address:  233 Canyon Rd Salt Lake City UT 84103   Deadline:  EOD   Weight:  2   Note:  Can only be on truck 2   Status & Time:  Delivered @ 09:54:20
ID:  4   Address:  380 W 2880 S Salt Lake City UT 84115   Deadline:  EOD   Weight:  4   Note:     Status & Time:  Delivered @ 08:35:00
ID:  5   Address:  410 S State St Salt Lake City UT 84111   Deadline:  EOD   Weight:  5   Note:     Status & Time:  Delivered @ 09:04:20
ID:  6   Address:  3060 Lester St West Valley City UT 84119   Deadline:  10:30 AM   Weight:  88   Note:  Delayed on flight---will not arrive to depot until 9:05 am   Status & Time:  Hub @ 09:05:00
ID:  7   Address:  1330 2100 S Salt Lake City UT 84106   Deadline:  EOD   Weight:  8   Note:     Status & Time:  Delivered @ 08:49:00
ID:  8   Address:  300 State St Salt Lake City UT 84103   Deadline:  EOD   Weight:  9   Note:     Status & Time:  Delivered @ 09:07:40
ID:  9   Address:  410 S State St Salt Lake City UT 84111   Deadline:  EOD   Weight:  2   Note:  Wrong address listed   Status & Time:  Delivered @ 09:07:40
ID:  10   Address:  600 E 900 South Salt Lake City UT 84105   Deadline:  EOD   Weight:  1   Note:     Status & Time:  Delivered @ 08:58:20
ID:  11   Address:  2600 Taylorsville Blvd Salt Lake City UT 84118   Deadline:  EOD   Weight:  1   Note:     Status & Time:  Enroute @ 08:00:00
ID:  12   Address:  3575 W Valley Central Station bus Loop West Valley City UT 84119   Deadline:  EOD   Weight:  1   Note:     Status & Time:  Delivered @ 09:45:40
ID:  13   Address:  2010 W 500 S Salt Lake City UT 84104   Deadline:  10:30 AM   Weight:  2   Note:     Status & Time:  Delivered @ 09:21:40
ID:  14   Address:  4300 S 1300 E Millcreek UT 84117   Deadline:  10:30 AM   Weight:  88   Note:  Must be delivered with 15, 19   Status & Time:  Delivered @ 08:06:20
ID:  15   Address:  4580 S 2300 E Holladay UT 84117   Deadline:  9:00 AM   Weight:  4   Note:     Status & Time:  Delivered @ 08:13:00
ID:  16   Address:  4580 S 2300 E Holladay UT 84117   Deadline:  10:30 AM   Weight:  88   Note:  Must be delivered with 13, 19   Status & Time:  Delivered @ 08:13:00
ID:  17   Address:  3148 S 1100 W Salt Lake City UT 84119   Deadline:  EOD   Weight:  2   Note:     Status & Time:  Enroute @ 08:00:00
ID:  18   Address:  1488 4800 S Salt Lake City UT 84123   Deadline:  EOD   Weight:  6   Note:  Can only be on truck 2   Status & Time:  Enroute @ 08:00:00
ID:  19   Address:  177 W Price Ave Salt Lake City UT 84115   Deadline:  EOD   Weight:  37   Note:     Status & Time:  Delivered @ 08:08:20
ID:  20   Address:  3595 Main St Salt Lake City UT 84115   Deadline:  10:30 AM   Weight:  37   Note:  Must be delivered with 13, 15   Status & Time:  Delivered @ 08:29:40
ID:  21   Address:  3595 Main St Salt Lake City UT 84115   Deadline:  EOD   Weight:  3   Note:     Status & Time:  Delivered @ 08:06:40
ID:  22   Address:  6351 South 900 East Murray UT 84121   Deadline:  EOD   Weight:  2   Note:     Status & Time:  Delivered @ 08:26:40
ID:  23   Address:  5100 South 2700 West Salt Lake City UT 84118   Deadline:  EOD   Weight:  5   Note:     Status & Time:  Enroute @ 08:00:00
ID:  24   Address:  5025 State St Murray UT 84107   Deadline:  EOD   Weight:  7   Note:     Status & Time:  Delivered @ 08:16:40
ID:  25   Address:  5383 South 900 East #104 Salt Lake City UT 84117   Deadline:  10:30 AM   Weight:  7   Note:  Delayed on flight---will not arrive to depot until 9:05 am   Status & Time:  Hub @ 09:05:00
ID:  26   Address:  5383 South 900 East #104 Salt Lake City UT 84117   Deadline:  EOD   Weight:  25   Note:     Status & Time:  Delivered @ 08:22:20
```

```
ID:  27   Address:  1060 Dalton Ave S Salt Lake City UT 84104   Deadline:  EOD   Weight:  5   Note:     Status & Time:  Delivered @ 09:38:20
ID:  28   Address:  2835 Main St Salt Lake City UT 84115   Deadline:  EOD   Weight:  7   Note:  Delayed on flight---will not arrive to depot until 9:05 am   Status & Time:  Hub @ 09:05:00
ID:  29   Address:  1330 2100 S Salt Lake City UT 84106   Deadline:  10:30 AM   Weight:  2   Note:     Status & Time:  Delivered @ 08:59:00
ID:  30   Address:  300 State St Salt Lake City UT 84103   Deadline:  10:30 AM   Weight:  1   Note:     Status & Time:  Delivered @ 09:56:20
ID:  31   Address:  3365 S 900 W Salt Lake City UT 84119   Deadline:  10:30 AM   Weight:  1   Note:     Status & Time:  Delivered @ 09:17:40
ID:  32   Address:  3365 S 900 W Salt Lake City UT 84119   Deadline:  EOD   Weight:  1   Note:  Delayed on flight---will not arrive to depot until 9:05 am   Status & Time:  Hub @ 09:05:00
ID:  33   Address:  2530 S 500 E Salt Lake City UT 84106   Deadline:  EOD   Weight:  1   Note:     Status & Time:  Delivered @ 09:04:20
ID:  34   Address:  4580 S 2300 E Holladay UT 84117   Deadline:  10:30 AM   Weight:  2   Note:     Status & Time:  Delivered @ 08:42:20
ID:  35   Address:  1060 Dalton Ave S Salt Lake City UT 84104   Deadline:  EOD   Weight:  88   Note:     Status & Time:  Hub @ 08:00:00
ID:  36   Address:  2300 Parkway Blvd West Valley City UT 84119   Deadline:  EOD   Weight:  88   Note:  Can only be on truck 2   Status & Time:  Delivered @ 09:29:00
ID:  37   Address:  410 S State St Salt Lake City UT 84111   Deadline:  10:30 AM   Weight:  2   Note:     Status & Time:  Hub @ 08:00:00
ID:  38   Address:  410 S State St Salt Lake City UT 84111   Deadline:  EOD   Weight:  9   Note:  Can only be on truck 2   Status & Time:  Delivered @ 09:59:40
ID:  39   Address:  2010 W 500 S Salt Lake City UT 84104   Deadline:  EOD   Weight:  9   Note:     Status & Time:  Hub @ 08:00:00
ID:  40   Address:  380 W 2880 S Salt Lake City UT 84115   Deadline:  10:30 AM   Weight:  45   Note:     Status & Time:  Hub @ 08:00:00
```

Screenshot 12:30 pm:

```
C:\Users\Louis\PycharmProjects\C950_Projectv3\venv\Scripts\python.exe C:/Users/Louis/PycharmProjects/C950_Projectv3/main.py
Truck 1 depart at 08:00:00
Truck 1 is back at 10:24:20
Truck 2 depart at 08:00:00
Truck 2 is back at 10:37:00
Truck 3 depart at 10:24:20
Truck 3 is back at 11:29:40

--- THE MAIN MENU ---
 Enter A Number:    1.Get_All_Packages  2.Get_Package_By_ID     3.Get_Total_Mileage
1
Enter the Time(HH:MM:SS):
12:30:00
ID:  1   Address:  195 W Oakland Ave Salt Lake City UT 84115   Deadline:  10:30 AM   Weight:  21   Note:     Status & Time:  Delivered @ 08:38:40
ID:  2   Address:  2530 S 500 E Salt Lake City UT 84106   Deadline:  EOD   Weight:  44   Note:     Status & Time:  Delivered @ 08:43:40
ID:  3   Address:  233 Canyon Rd Salt Lake City UT 84103   Deadline:  EOD   Weight:  2   Note:  Can only be on truck 2   Status & Time:  Delivered @ 09:54:20
ID:  4   Address:  380 W 2880 S Salt Lake City UT 84115   Deadline:  EOD   Weight:  4   Note:     Status & Time:  Delivered @ 08:35:00
ID:  5   Address:  410 S State St Salt Lake City UT 84111   Deadline:  EOD   Weight:  5   Note:     Status & Time:  Delivered @ 09:04:20
ID:  6   Address:  3060 Lester St West Valley City UT 84119   Deadline:  10:30 AM   Weight:  88   Note:  Delayed on flight---will not arrive to depot until 9:05 am   Status & Time:  Delivered @ 11:03:40
ID:  7   Address:  1330 2100 S Salt Lake City UT 84106   Deadline:  EOD   Weight:  8   Note:     Status & Time:  Delivered @ 08:49:00
ID:  8   Address:  300 State St Salt Lake City UT 84103   Deadline:  EOD   Weight:  9   Note:     Status & Time:  Delivered @ 09:07:40
ID:  9   Address:  410 S State St Salt Lake City UT 84111   Deadline:  EOD   Weight:  2   Note:  Wrong address listed   Status & Time:  Delivered @ 09:07:40
ID:  10   Address:  600 E 900 South Salt Lake City UT 84105   Deadline:  EOD   Weight:  1   Note:     Status & Time:  Delivered @ 08:58:20
ID:  11   Address:  2600 Taylorsville Blvd Salt Lake City UT 84118   Deadline:  EOD   Weight:  1   Note:     Status & Time:  Delivered @ 10:24:20
ID:  12   Address:  3575 W Valley Central Station bus Loop West Valley City UT 84119   Deadline:  EOD   Weight:  1   Note:     Status & Time:  Delivered @ 09:45:40
ID:  13   Address:  2010 W 500 S Salt Lake City UT 84104   Deadline:  10:30 AM   Weight:  2   Note:     Status & Time:  Delivered @ 09:21:40
ID:  14   Address:  4300 S 1300 E Millcreek UT 84117   Deadline:  10:30 AM   Weight:  88   Note:  Must be delivered with 15, 19   Status & Time:  Delivered @ 08:06:20
ID:  15   Address:  4580 S 2300 E Holladay UT 84117   Deadline:  9:00 AM   Weight:  4   Note:     Status & Time:  Delivered @ 08:13:00
ID:  16   Address:  4580 S 2300 E Holladay UT 84117   Deadline:  10:30 AM   Weight:  88   Note:  Must be delivered with 13, 19   Status & Time:  Delivered @ 08:13:00
ID:  17   Address:  3148 S 1100 W Salt Lake City UT 84119   Deadline:  EOD   Weight:  2   Note:     Status & Time:  Delivered @ 10:07:00
ID:  18   Address:  1488 4800 S Salt Lake City UT 84123   Deadline:  EOD   Weight:  6   Note:  Can only be on truck 2   Status & Time:  Delivered @ 10:35:00
ID:  19   Address:  177 W Price Ave Salt Lake City UT 84115   Deadline:  EOD   Weight:  37   Note:     Status & Time:  Delivered @ 08:08:20
ID:  20   Address:  3595 Main St Salt Lake City UT 84115   Deadline:  10:30 AM   Weight:  37   Note:  Must be delivered with 13, 15   Status & Time:  Delivered @ 08:29:40
ID:  21   Address:  3595 Main St Salt Lake City UT 84115   Deadline:  EOD   Weight:  3   Note:     Status & Time:  Delivered @ 08:06:40
ID:  22   Address:  6351 South 900 East Murray UT 84121   Deadline:  EOD   Weight:  2   Note:     Status & Time:  Delivered @ 08:26:40
ID:  23   Address:  5100 South 2700 West Salt Lake City UT 84118   Deadline:  EOD   Weight:  5   Note:     Status & Time:  Delivered @ 10:37:00
ID:  24   Address:  5025 State St Murray UT 84107   Deadline:  EOD   Weight:  7   Note:     Status & Time:  Delivered @ 08:16:40
ID:  25   Address:  5383 South 900 East #104 Salt Lake City UT 84117   Deadline:  10:30 AM   Weight:  7   Note:  Delayed on flight---will not arrive to depot until 9:05 am   Status & Time:  Delivered @ 10:32:20
ID:  26   Address:  5383 South 900 East #104 Salt Lake City UT 84117   Deadline:  EOD   Weight:  25   Note:     Status & Time:  Delivered @ 08:22:20
```

```
ID:  27   Address:  1060 Dalton Ave S Salt Lake City UT 84104   Deadline:  EOD   Weight:  5   Note:     Status & Time:  Delivered @ 09:38:20
ID:  28   Address:  2835 Main St Salt Lake City UT 84115   Deadline:  EOD   Weight:  7   Note:  Delayed on flight---will not arrive to depot until 9:05 am   Status & Time:  Delivered @ 10:49:40
ID:  29   Address:  1330 2100 S Salt Lake City UT 84106   Deadline:  10:30 AM   Weight:  2   Note:     Status & Time:  Delivered @ 08:59:00
ID:  30   Address:  300 State St Salt Lake City UT 84103   Deadline:  10:30 AM   Weight:  1   Note:     Status & Time:  Delivered @ 09:56:20
ID:  31   Address:  3365 S 900 W Salt Lake City UT 84119   Deadline:  10:30 AM   Weight:  1   Note:     Status & Time:  Delivered @ 09:17:40
ID:  32   Address:  3365 S 900 W Salt Lake City UT 84119   Deadline:  EOD   Weight:  1   Note:  Delayed on flight---will not arrive to depot until 9:05 am   Status & Time:  Delivered @ 10:58:40
ID:  33   Address:  2530 S 500 E Salt Lake City UT 84106   Deadline:  EOD   Weight:  1   Note:     Status & Time:  Delivered @ 09:04:20
ID:  34   Address:  4580 S 2300 E Holladay UT 84117   Deadline:  10:30 AM   Weight:  2   Note:     Status & Time:  Delivered @ 08:42:20
ID:  35   Address:  1060 Dalton Ave S Salt Lake City UT 84104   Deadline:  EOD   Weight:  88   Note:     Status & Time:  Delivered @ 11:13:40
ID:  36   Address:  2300 Parkway Blvd West Valley City UT 84119   Deadline:  EOD   Weight:  88   Note:  Can only be on truck 2   Status & Time:  Delivered @ 09:29:00
ID:  37   Address:  410 S State St Salt Lake City UT 84111   Deadline:  10:30 AM   Weight:  2   Note:     Status & Time:  Delivered @ 11:29:40
ID:  38   Address:  410 S State St Salt Lake City UT 84111   Deadline:  EOD   Weight:  9   Note:  Can only be on truck 2   Status & Time:  Delivered @ 09:59:40
ID:  39   Address:  2010 W 500 S Salt Lake City UT 84104   Deadline:  EOD   Weight:  9   Note:     Status & Time:  Delivered @ 11:19:00
ID:  40   Address:  380 W 2880 S Salt Lake City UT 84115   Deadline:  10:30 AM   Weight:  45   Note:     Status & Time:  Delivered @ 10:53:00
```

Screenshot Total Mileage:

```
C:\Users\Louis\PycharmProjects\C950_Projectv3\venv\Scripts\python.exe C:/Users/Louis/PycharmProjects/C950_Projectv3/main.py
Truck 1 depart at 08:00:00
Truck 1 is back at 10:24:20
Truck 2 depart at 08:00:00
Truck 2 is back at 10:37:00
Truck 3 depart at 10:24:20
Truck 3 is back at 11:29:40

--- THE MAIN MENU ---
 Enter A Number:    1.Get_All_Packages  2.Get_Package_By_ID     3.Get_Total_Mileage
3
Total Mileage Driven:  110
```

Core Algorithm

Overall the program is most time complexity is focused on the Get Route Path( ) using the Greedy Algorithm which is the core algorithm in this program, we choose this algorithm since the restriction mileage is not too tight, this algorithm is relative light, yet it produces good enough result to find the locally optimal path for each node, there is the more in-depth way we can compute. However that will increase the computation, it might be small at first, if the node's amount is scaled to a large amount, the computation will increase exponentially.

For example, if we are only seeking optimization we can look at multiple layers of depth to design the solution, it may be more optimal but it is much computation O(n!), we can look through d number of depth or simply **all possible permutation** of nodes before decide.

In another case, if n is so large, even looking through n is too much, we can use a **breadth-first search** and set certain criteria to find an element that satisfies a certain distance. For example, instead of looking, n times for local optimal, we can just set whichever vertex under 10 miles or 15 miles, just adjust till it fits best. However, this is far from the best solution.

Let's say if computation complexity is not a concern, do this project again, to get the most optimal solution, also known as the **global optimal**. We can get a route by looking into finding every single possible route of n! and then compare them all.

Look Up Function

The look-up function will need O(n) to O(1) to compete since we use a self-adaptive structure such as a hash table.

As packages amount changes the computation required more, since more elements are stored in the same bin, however, we can reduce computation back by increasing the bin in the hash table.

Adding more trucks will decrease the computation of each individual truck since the work is shared. Increasing the city will increase the computation dramatically since most computation is highly tight to the permutation of the number of nodes.

Some other data structures can be used, like **binary search**, or **binary tree algorithm**. For binary search, we can store everything in a long list, and looking through them compare numbers, discard half, and keep half. etc. The time complexity on this is O(log n), which is also very efficient, the only thing is that it is not as flexible as Hash Table, where we can adjust the number of the bin to reduce memory if needed. Another method we can use is any binary tree algorithm. Essentially we have to sort and store them as a binary tree graph, which also has a time complexity of O(log n). The only downside to this is things will store in a nested tree format, which is not very human-readable like the binary search where we store things like a long list of yellow pages. Nonetheless, both of these data structure is very efficient and does the job.

Programing Environment

Window 10/11, Python 3.9, PyCharm 2021.3.1 (Community Edition)

Libraries Used

Python Only, No Other 3rd Party Libraries Used

Project Link and Source Code

Command Line Application in Python:

https://github.com/GiggleSamurai/Data-Structure-Graphs-Optimization-Problem-Solving.git

NOTICE: The URL links are **not** clickable from GitHub pdf rendering, please download the pdf to click on the links. You can also access the project from the directory folder of this document. Both data set and project are contained in this folder.