C950 WGUPS Algorithm Overview

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C950 Data Structures and Algorithms II

Introduction

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A. Algorithm Identification

The algorithm used within the project is a Greedy Algorithm, which just looks at all the packages left on a truck and delivers the next closest one.

B1. Logic Comments

```
Create Empty HashMap
Read Package Data objects into HashMap
Read Distance table
Read Address List
Create a Address List Dictionary( Address:Address ID)
Create truck objects
Load Truck 1
    While packages are still on truck deliver package method
    if the truck is empty return to hub method and set truck 3 departing time to the same as truck 1 arival time
Load Truck 2
    While packages are still on truck deliver package method
    if truck is empty return to hub method
Load Truck 3
    While packages are still on truck deliver packages
    if truck is empty return to hub method
Print Delivery Times and Distances
Main Menu to search for package
    1 Look up single package, ask for time and package id
    2 Show all packages, ask for time
    3 Exit
```

Deliver_package(truck)

Call find next shortest delivery to find next package to deliver

Updates locations of truck, distance driven, time of package delivery

find_next_shortest_delivery(truck)

Loops through package list to find the shortest distance in the packages list on the passed in truck object and returns the package object

B2. Development Environment

This program was built on Pop_OS! 22.04 in Pycharm 2022.2.1 on python 3.9. Computer is a Dell XPS 15 7590 i7-9750H and 32GB of ram

B3. Space-Time and Big-O

Name	Time-Complexity
Main.py	O(n)
read_package_data	O(n)
read_distance_data	O(1)
read_address_data	O(1)
distance_between	O(1)
find_next_shortest_delivery	O(n)
create_address_dic	O(n)
load_truck	O(n)
deliver_package	O(1)
return_to_hub	O(1)
Package.py	O(n)
package_delivery_status_at_time	O(n)
Truck.py	O(n)
load_package	O(1)
package_delivered	O(1)
hash_table.py	O(n^2)
_get_hash	O(n)
Add	O(n)
Get	O(n)

Delete	O(n)
Keys	O(n)
return_all_iems	O(n^2)

B4. Scalability and Adaptability

This application underlying data structure is very scalable, as the hash map will adapt its size to fit as many packages as passed into it.

B5. Software Efficiency and Maintainability

The efficiency of the code at worst case is O(n^2), but that is only for if you need to retrieve all items in the hash map. The delivery algo runs in O(n) time so I would say its very Efficient. The efficiency of the delivery times and distance mostly relies on careful ordering of packages onto trucks.

B6. Self-Adjusting Data Structures

A HashMap was used as the self adjusting data structure

Strengths	Weaknesses
Speed in which to access items	Does not allow null or empty values
Insertion time complexity = O(1) on new keys	Linearly slower as the load factor increases
Can grow as large as memory space allows	

D. Data Structure

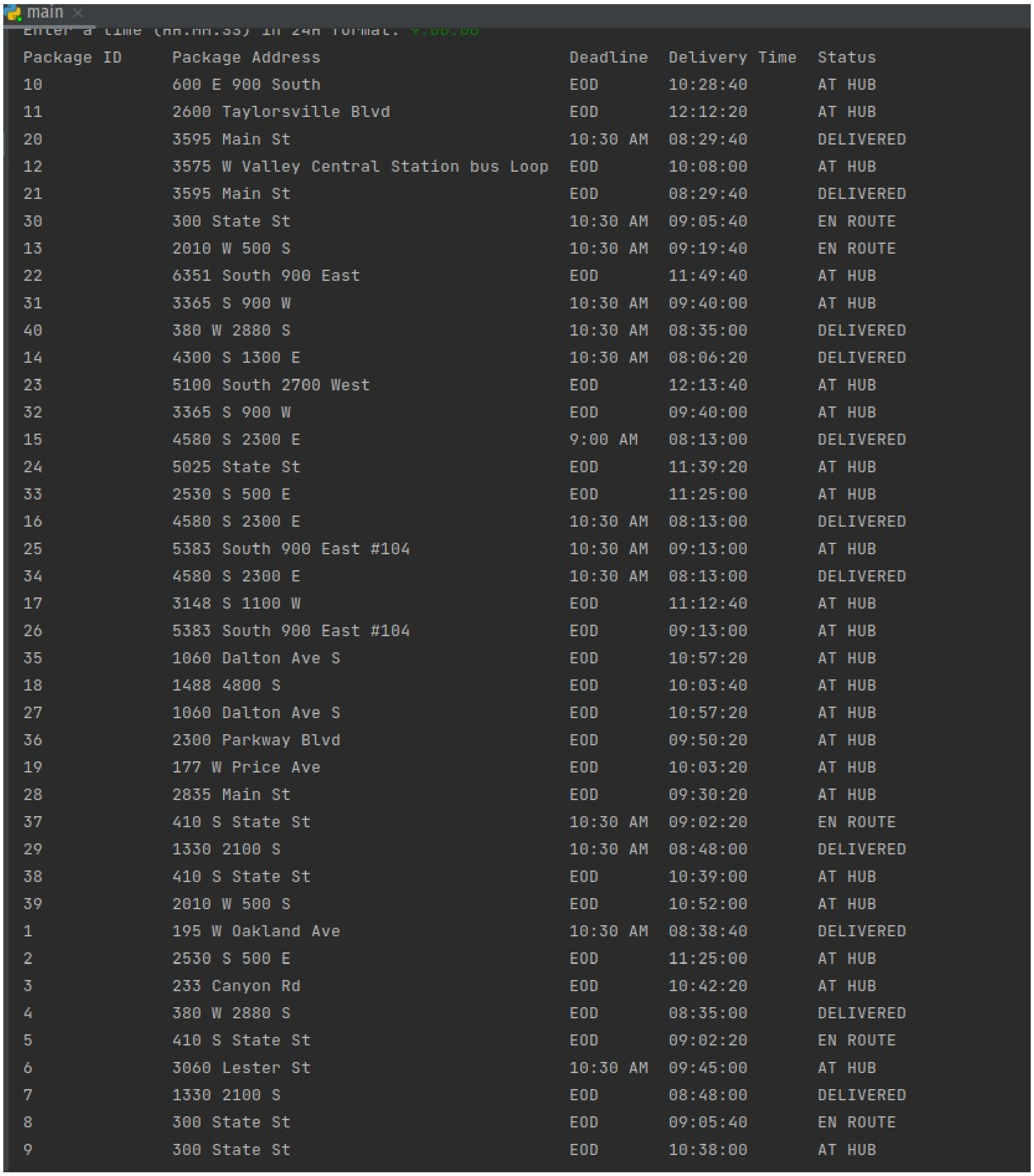
I used a chaining hash table with linear probing for retrieval as the self-adjusting data structure

D1. Explanation of Data Structure

The chaining has table can perform insertion and deletion. The insertion function also performs the update action if provided with the same object. The chaining hash table does perform slower then a standard hashing but avoids the issue of hash collisions. The find_next_shortest_delivery uses the unique package ID value of the package to retrieve objects from the hash table.

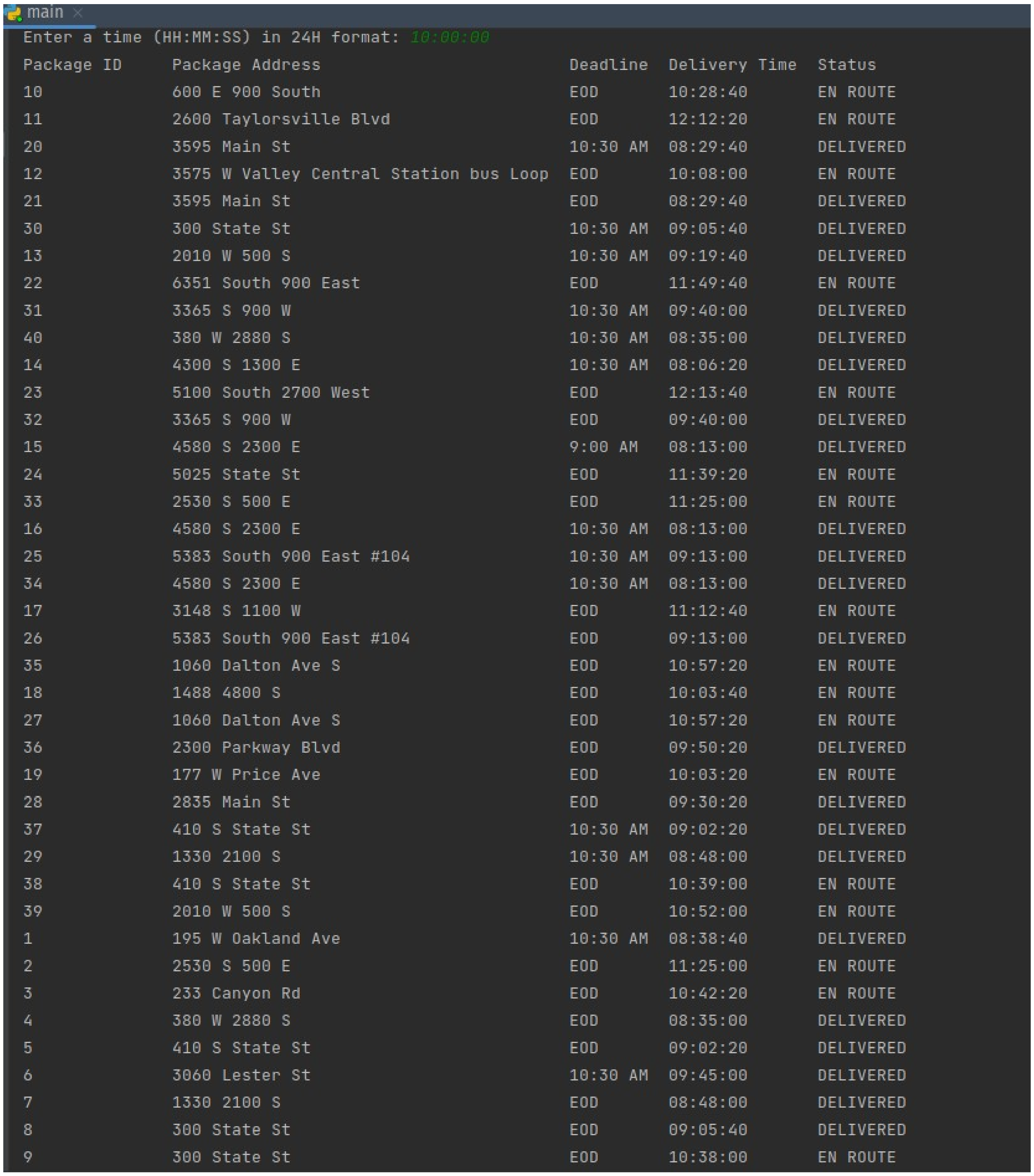
The table has 3 basic functions. Add, get, delete. Add adds or updates a item in the table. Get returns and item based on the key provided, and delete deletes a item based on the key provided.

G1. First Status Check



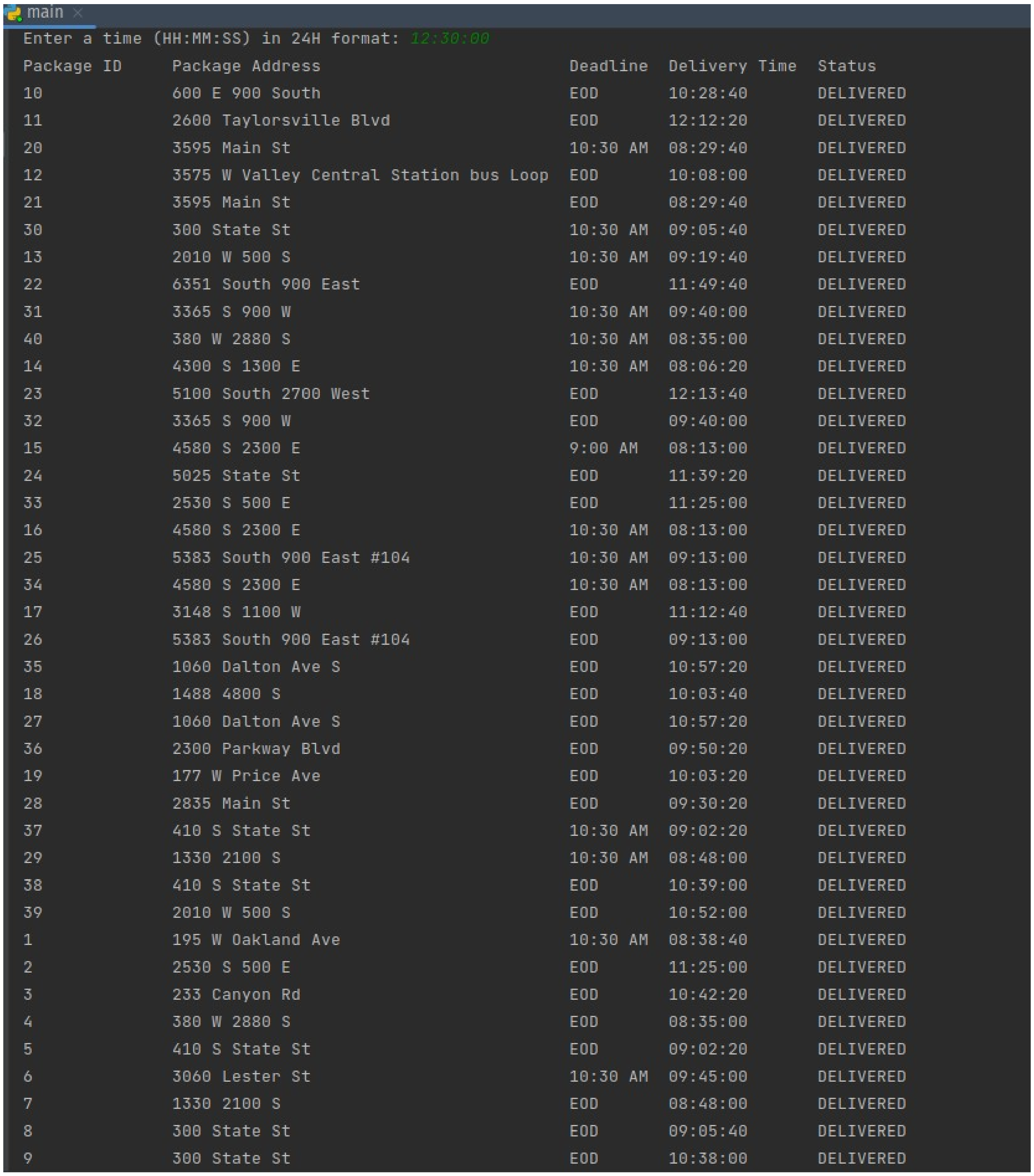
```
Enter a time (HH:MM:SS) in 24H format: 9:00:00
Package ID     Package Address                          Deadline   Delivery Time   Status
10             600 E 900 South                          EOD        10:28:40        AT HUB
11             2600 Taylorsville Blvd                   EOD        12:12:20        AT HUB
20             3595 Main St                             10:30 AM   08:29:40        DELIVERED
12             3575 W Valley Central Station bus Loop   EOD        10:08:00        AT HUB
21             3595 Main St                             EOD        08:29:40        DELIVERED
30             300 State St                             10:30 AM   09:05:40        EN ROUTE
13             2010 W 500 S                             10:30 AM   09:19:40        EN ROUTE
22             6351 South 900 East                      EOD        11:49:40        AT HUB
31             3365 S 900 W                             10:30 AM   09:40:00        AT HUB
40             380 W 2880 S                             10:30 AM   08:35:00        DELIVERED
14             4300 S 1300 E                            10:30 AM   08:06:20        DELIVERED
23             5100 South 2700 West                     EOD        12:13:40        AT HUB
32             3365 S 900 W                             EOD        09:40:00        AT HUB
15             4580 S 2300 E                            9:00 AM    08:13:00        DELIVERED
24             5025 State St                            EOD        11:39:20        AT HUB
33             2530 S 500 E                             EOD        11:25:00        AT HUB
16             4580 S 2300 E                            10:30 AM   08:13:00        DELIVERED
25             5383 South 900 East #104                 10:30 AM   09:13:00        AT HUB
34             4580 S 2300 E                            10:30 AM   08:13:00        DELIVERED
17             3148 S 1100 W                            EOD        11:12:40        AT HUB
26             5383 South 900 East #104                 EOD        09:13:00        AT HUB
35             1060 Dalton Ave S                        EOD        10:57:20        AT HUB
18             1488 4800 S                              EOD        10:03:40        AT HUB
27             1060 Dalton Ave S                        EOD        10:57:20        AT HUB
36             2300 Parkway Blvd                        EOD        09:50:20        AT HUB
19             177 W Price Ave                          EOD        10:03:20        AT HUB
28             2835 Main St                             EOD        09:30:20        AT HUB
37             410 S State St                           10:30 AM   09:02:20        EN ROUTE
29             1330 2100 S                              10:30 AM   08:48:00        DELIVERED
38             410 S State St                           EOD        10:39:00        AT HUB
39             2010 W 500 S                             EOD        10:52:00        AT HUB
1              195 W Oakland Ave                        10:30 AM   08:38:40        DELIVERED
2              2530 S 500 E                             EOD        11:25:00        AT HUB
3              233 Canyon Rd                            EOD        10:42:20        AT HUB
4              380 W 2880 S                             EOD        08:35:00        DELIVERED
5              410 S State St                           EOD        09:02:20        EN ROUTE
6              3060 Lester St                           10:30 AM   09:45:00        AT HUB
7              1330 2100 S                              EOD        08:48:00        DELIVERED
8              300 State St                             EOD        09:05:40        EN ROUTE
9              300 State St                             EOD        10:38:00        AT HUB
```

G2. Second Status Check



```
main
Enter a time (HH:MM:SS) in 24H format: 10:00:00
Package ID     Package Address                         Deadline  Delivery Time  Status
10             600 E 900 South                         EOD       10:28:40       EN ROUTE
11             2600 Taylorsville Blvd                  EOD       12:12:20       EN ROUTE
20             3595 Main St                            10:30 AM  08:29:40       DELIVERED
12             3575 W Valley Central Station bus Loop  EOD       10:08:00       EN ROUTE
21             3595 Main St                            EOD       08:29:40       DELIVERED
30             300 State St                            10:30 AM  09:05:40       DELIVERED
13             2010 W 500 S                            10:30 AM  09:19:40       DELIVERED
22             6351 South 900 East                     EOD       11:49:40       EN ROUTE
31             3365 S 900 W                            10:30 AM  09:40:00       DELIVERED
40             380 W 2880 S                            10:30 AM  08:35:00       DELIVERED
14             4300 S 1300 E                           10:30 AM  08:06:20       DELIVERED
23             5100 South 2700 West                    EOD       12:13:40       EN ROUTE
32             3365 S 900 W                            EOD       09:40:00       DELIVERED
15             4580 S 2300 E                           9:00 AM   08:13:00       DELIVERED
24             5025 State St                           EOD       11:39:20       EN ROUTE
33             2530 S 500 E                            EOD       11:25:00       EN ROUTE
16             4580 S 2300 E                           10:30 AM  08:13:00       DELIVERED
25             5383 South 900 East #104                10:30 AM  09:13:00       DELIVERED
34             4580 S 2300 E                           10:30 AM  08:13:00       DELIVERED
17             3148 S 1100 W                           EOD       11:12:40       EN ROUTE
26             5383 South 900 East #104                EOD       09:13:00       DELIVERED
35             1060 Dalton Ave S                       EOD       10:57:20       EN ROUTE
18             1488 4800 S                             EOD       10:03:40       EN ROUTE
27             1060 Dalton Ave S                       EOD       10:57:20       EN ROUTE
36             2300 Parkway Blvd                       EOD       09:50:20       DELIVERED
19             177 W Price Ave                         EOD       10:03:20       EN ROUTE
28             2835 Main St                            EOD       09:30:20       DELIVERED
37             410 S State St                          10:30 AM  09:02:20       DELIVERED
29             1330 2100 S                             10:30 AM  08:48:00       DELIVERED
38             410 S State St                          EOD       10:39:00       EN ROUTE
39             2010 W 500 S                            EOD       10:52:00       EN ROUTE
1              195 W Oakland Ave                       10:30 AM  08:38:40       DELIVERED
2              2530 S 500 E                            EOD       11:25:00       EN ROUTE
3              233 Canyon Rd                           EOD       10:42:20       EN ROUTE
4              380 W 2880 S                            EOD       08:35:00       DELIVERED
5              410 S State St                          EOD       09:02:20       DELIVERED
6              3060 Lester St                          10:30 AM  09:45:00       DELIVERED
7              1330 2100 S                             EOD       08:48:00       DELIVERED
8              300 State St                            EOD       09:05:40       DELIVERED
9              300 State St                            EOD       10:38:00       EN ROUTE
```

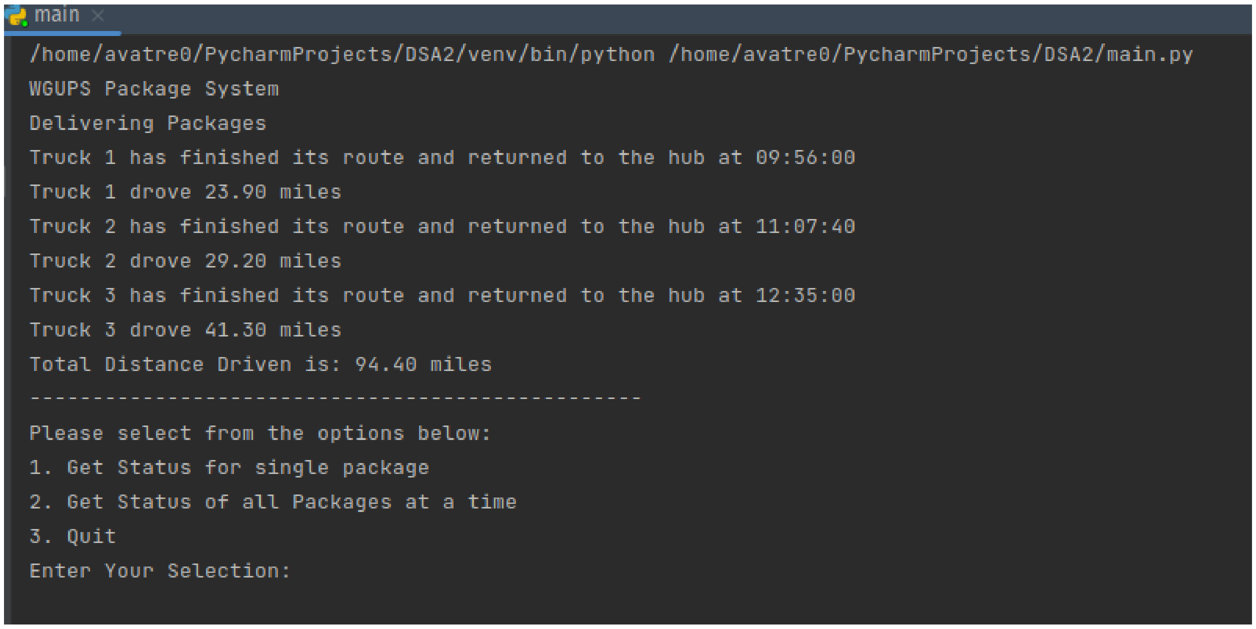
G3. Third Status Check



main

```
Enter a time (HH:MM:SS) in 24H format: 12:30:00
Package ID     Package Address                        Deadline  Delivery Time  Status
10             600 E 900 South                        EOD       10:28:40       DELIVERED
11             2600 Taylorsville Blvd                 EOD       12:12:20       DELIVERED
20             3595 Main St                           10:30 AM  08:29:40       DELIVERED
12             3575 W Valley Central Station bus Loop EOD       10:08:00       DELIVERED
21             3595 Main St                           EOD       08:29:40       DELIVERED
30             300 State St                           10:30 AM  09:05:40       DELIVERED
13             2010 W 500 S                           10:30 AM  09:19:40       DELIVERED
22             6351 South 900 East                    EOD       11:49:40       DELIVERED
31             3365 S 900 W                           10:30 AM  09:40:00       DELIVERED
40             380 W 2880 S                           10:30 AM  08:35:00       DELIVERED
14             4300 S 1300 E                          10:30 AM  08:06:20       DELIVERED
23             5100 South 2700 West                   EOD       12:13:40       DELIVERED
32             3365 S 900 W                           EOD       09:40:00       DELIVERED
15             4580 S 2300 E                          9:00 AM   08:13:00       DELIVERED
24             5025 State St                          EOD       11:39:20       DELIVERED
33             2530 S 500 E                           EOD       11:25:00       DELIVERED
16             4580 S 2300 E                          10:30 AM  08:13:00       DELIVERED
25             5383 South 900 East #104               10:30 AM  09:13:00       DELIVERED
34             4580 S 2300 E                          10:30 AM  08:13:00       DELIVERED
17             3148 S 1100 W                          EOD       11:12:40       DELIVERED
26             5383 South 900 East #104               EOD       09:13:00       DELIVERED
35             1060 Dalton Ave S                      EOD       10:57:20       DELIVERED
18             1488 4800 S                            EOD       10:03:40       DELIVERED
27             1060 Dalton Ave S                      EOD       10:57:20       DELIVERED
36             2300 Parkway Blvd                      EOD       09:50:20       DELIVERED
19             177 W Price Ave                        EOD       10:03:20       DELIVERED
28             2835 Main St                           EOD       09:30:20       DELIVERED
37             410 S State St                         10:30 AM  09:02:20       DELIVERED
29             1330 2100 S                            10:30 AM  08:48:00       DELIVERED
38             410 S State St                         EOD       10:39:00       DELIVERED
39             2010 W 500 S                           EOD       10:52:00       DELIVERED
1              195 W Oakland Ave                      10:30 AM  08:38:40       DELIVERED
2              2530 S 500 E                           EOD       11:25:00       DELIVERED
3              233 Canyon Rd                          EOD       10:42:20       DELIVERED
4              380 W 2880 S                           EOD       08:35:00       DELIVERED
5              410 S State St                         EOD       09:02:20       DELIVERED
6              3060 Lester St                         10:30 AM  09:45:00       DELIVERED
7              1330 2100 S                            EOD       08:48:00       DELIVERED
8              300 State St                           EOD       09:05:40       DELIVERED
9              300 State St                           EOD       10:38:00       DELIVERED
```

H. Screenshots of Code Execution



```
/home/avatre0/PycharmProjects/DSA2/venv/bin/python /home/avatre0/PycharmProjects/DSA2/main.py
WGUPS Package System
Delivering Packages
Truck 1 has finished its route and returned to the hub at 09:56:00
Truck 1 drove 23.90 miles
Truck 2 has finished its route and returned to the hub at 11:07:40
Truck 2 drove 29.20 miles
Truck 3 has finished its route and returned to the hub at 12:35:00
Truck 3 drove 41.30 miles
Total Distance Driven is: 94.40 miles
-------------------------------------------------
Please select from the options below:
1. Get Status for single package
2. Get Status of all Packages at a time
3. Quit
Enter Your Selection:
```

I1. Strengths of Chosen Algorithm

Accuracy: This algorithm delivers the packages on time and under millage. Delivering the packages in 94.40 miles.

Efficiency: The greedy algorithm is O(n) and thus is very efficient, and easy to implement

I3. Other possible Algorithms

Other possible approaches include:

Brute force algorithm.

Dijkstra's algorithm

I3A. Algorithm Differences

	Brute Force	Dijkstra	Greedy
Time Complexity	O(n*m)	O(n^2)	O(n)
Advantages	Finds all routes	Low relative complexity	Easy to implement and low complexity

J. Different Approach

If I were to do this project again I would change the following,

Package assignment. As it is now, in order for the packages to be delivers on time and with the special requirements (only arriving at 9:05, only on truck 2, being delivered with other packages etc), requires the packages to be pre-sorted by hand onto the tucks. I would like to develop some auto sorting algo possibly based on zip code. Also this would require the package objects to have flags for the special requirements.

K1. Verification of Data Structure

The chaining hash table, meets all requirements. It delivered the packages in a total of 94.40 miles. All packages were delivered before deadlines. The table was also able to quickly lookup data inside it.

K1A. Efficiency

The worst case for lookup on the hash table is O(n). This table uses linear probing to find the packages. As packages are added the time to perform the lookup will increase.

K1B. Overhead

As packages are added to the hash table, the likelihood of hash collisions increases, increasing the size of the table. This also affects lookup time as the table will not only need to find the key in the hash, but then find the object in the linked list at the key. To combat this we can increase the size of the table at creation.

K1C. Implications

Changing the number of trucks will not increase the lookup time or space requirement of the hash table. The table does not store data based on trucks. Like wise changing he number of cities shouldn’t make any difference in the lookup process or time-space complexities.

The map only contains package object data, unless we add more packages there should be no changes to the lookup time or time-space complexities.

K2. Other Data Structures

Two other data structures that could be used are

1) Weighted Graph

2) Stack

K2a. Data Structure Differences

Stack: A stack could be created with the order in which packages are to be delivered. You push the item on the stack then pop them off to get the next package to be delivered. This would be more space efficient, but would require pre-loading of the trucks and finding the best path between them before pushing them onto the stack

Weighted Graph: Nodes would represent package delivery addresses. This would eliminate the need to find the next efficient route as it is built into the traversal. The graph would likely be more space-time efficient.