C950 Data Structures and Algorithms II
Task 1 Overview
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A) Identify a named self-adjusting algorithm (e.g., “Nearest Neighbor algorithm,” “Greedy algorithm”) that you used to create your program to deliver the packages.

My program uses a version of the Greedy Algorithm. This will help optimize the delivery based on the given scenario. The algorithm will look through the packets in each truck and compare the distances from the current location with the destination of each package. It will choose the destination with the shortest distance to the current location and then repeat until all packages are delivered.

B1) Explain the algorithm’s logic using pseudocode.

The program will load all the package information, addresses and distance information from corresponding csv files. The packages are loaded manually to each truck depending on special notes and delivery deadlines. The loaded trucks are then run by the greedy algorithm in order to deliver the packages on the specified truck.

Greedy Algorithm Pseudocode:

```
------------------------------------------------------------------------------------------------
Deliver Package for Truck #
        current location = hub
        total miles traveled = 0

        While packages still on truck

                for each package on truck
                        find distance between current location and package destination

                        if package destination is shortest distance set package destination as
                                        next location

        update current location with chosen next location
        add distance traveled to total miles traveled
        set delivery time to package
        remove delivered package from truck
--------------------------------------------------------------------------------------------------
```

The program will start the algorithm by asking for a parameter which will be the number of the truck that will be sent for deliveries. The truck will start at the hub and set that as our current location and start a counter for miles traveled by truck. As long as the truck still has packages the algorithm will run a for loop going through each package on the truck and comparing distances. The package with the shortest distance to the current distance will be chosen for delivery. After a package is chosen, the current location is updated with the address of the chosen package. The distance traveled is added to the total miles counter and the package information will be updated with the time it was delivered. Finally remove the package from the truck to mark it as delivered and repeat the process until the truck is empty.

B2) Describe the programming environment you used to create the Python application.

The delivery program was written in Visual Studio Code version 1.69.2. The programming language is python 3.10.6. The program was run in Visual Studio Code using the built-in terminal. The source files for python (.py) are saved on a localhost machine.

Localhost machine information:
OS: Windows 10 CPU: Ryzen 9

B3) Evaluate the space-time complexity of each major segment of the program, and the entire program, using big-O notation.

The overall run time of the program is 0(n^2) due to two major blocks of code. The Most important one being the Greedy algorithm used in order to deliver the packages. This algorithm has to loop through each truck and obtain its information such as truck ID, amount of packages, speed, and start time. Then after looping through the truck information we have to loop through each package and retrieve the package information from the truck and loop through each package to find an optimal route. So for every n package added means that the truck has too loop n more times and then compare n more packages when delivering giving it a time of 0(n^2).

Similarly the main class that prints out the information of all packages has a time of 0(n^2). This is due to the first loop having to search through the hash table for each package and comparing the time the user requested with the package time in order to set the package status. Then after looping through the hash table, a second loop is used in order to print out the package information with the correct status for the requested time with the information gathered by the prior loop.

Due to the nature of the hash table being a linked list and having to store packages in indexes, the amount of space increases linearly at a rate of 0(n). For example if we were to add more packages the amount of memory needed will increase linearly based on the amount of new packages added.

Overall Program run time: 0(n^2)
Main.py 0(n^2) + Hashmap.py 0(n) + Distance.py 0(n) + Csvreader.py 0(n^2)

Main.py	0(n^2)
Class Main	0(n^2)

Hashmap.py	0(n)
def init	0(n)
Get_hash	0(1)
Insert	0(n)
Search	0(n)
Delete	0(n)

Distance.py	0(n)
getAddressID	0(n)
getDistance	0(n)
getTime	0(1)

Csvreader.py	0(n^2)
DeliverPackage	0(n^2)
LoadAndDeliver	0(n)

B4) Explain the capability of your solution to scale and adapt to a growing number of packages.

The program was built with scalability in mind. By creating separate classes for the packages and trucks, it is easy to add more packages or trucks to the program with minimal programming needed. Loading a package on a truck is simple, just add the ID of the package to the truck number that is being loaded. The greedy algorithm will be able to replicate its function with any new trucks added.

If we are to expand the program by adding hundreds of packages, then the algorithm will have to be expanded in order to automate the package load with package filtering. The hash table size will have to be increased to fit the new quantity of packages. By expanding the size of the hash table we will be able to minimize the search times for packages. Similarly the amount of trucks added will have to increase. New trucks will be added and loaded based on package notes and delivery deadlines in order to effectively deliver more packages without passing the 16 package limit per truck.

B5) Discuss why the software is efficient and easy to maintain.

The Greedy algorithm is implemented so that it can be easy to understand and be able to follow the steps as packages are being delivered. The program is split into multiple packages making it simple to read and edit. For example if edits are required to the UI, refer to the main class, need to edit how the packages or trucks are laid out, refer to the package class or tuck class respectively. The data for packages, distance or address are all loaded in from a csv. Due to the program reading the csv data and creating its own list for each csv, it is easy to add or edit the data without making drastic changes to the code.

B6) Discuss the strengths and weaknesses of the self-adjusting data structures (e.g., the hash table).

One self adjusting aspect of the hash table is its ability to handle collisions. By adding collision handling and separating the data into keys and pairs, the hash table can have less items per index making retrieving information from the table faster and efficient.

Another strength of the hash table is the ability to update items with the built in insert function contained in this program. The insert function in this program will search to see if a given key has been taken in the hash table. If no key is found then the table will create a new key, however if a key is found we will replace the old key with the new key.

The Weakness of the hash table is, as the amount of items from table grows, the longer the retrieval times will be. This is due to having to search each index of the table until the correct pairs are found. This will also affect the speed at which items are added. As stated before the table will first search the table for identical keys and then add items based on the result of the search. The more items in the table, the more indexes the table will have to search and will slow the overall time of the program.

D1) Identify a self-adjusting data structure, such as a hash table, that can be used with the algorithm identified in part A to store the package data.

The program uses an array of linked lists known as a hash table. This table will be used to keep track of the package information in the program. The Greedy algorithm uses the hash table in order to keep track of the packages needed to be delivered.

The hash table functions by indexing data in an array. The packages will be indexed using the package id as a key. We will then index each package to the array by taking the modulo of the key's ASCII value and the amount of packages expected. We will insert package information by assigning a key and then indexing it to an index. If a key is found that matches a key already in the table we will instead update the information in the matching key. The search function will be used to retrieve package information by taking in a key as a parameter and then looking through each index until the matching pair is found. Similarly the delete function will also search for a key but instead of returning the pair we will delete the matching key from the array.

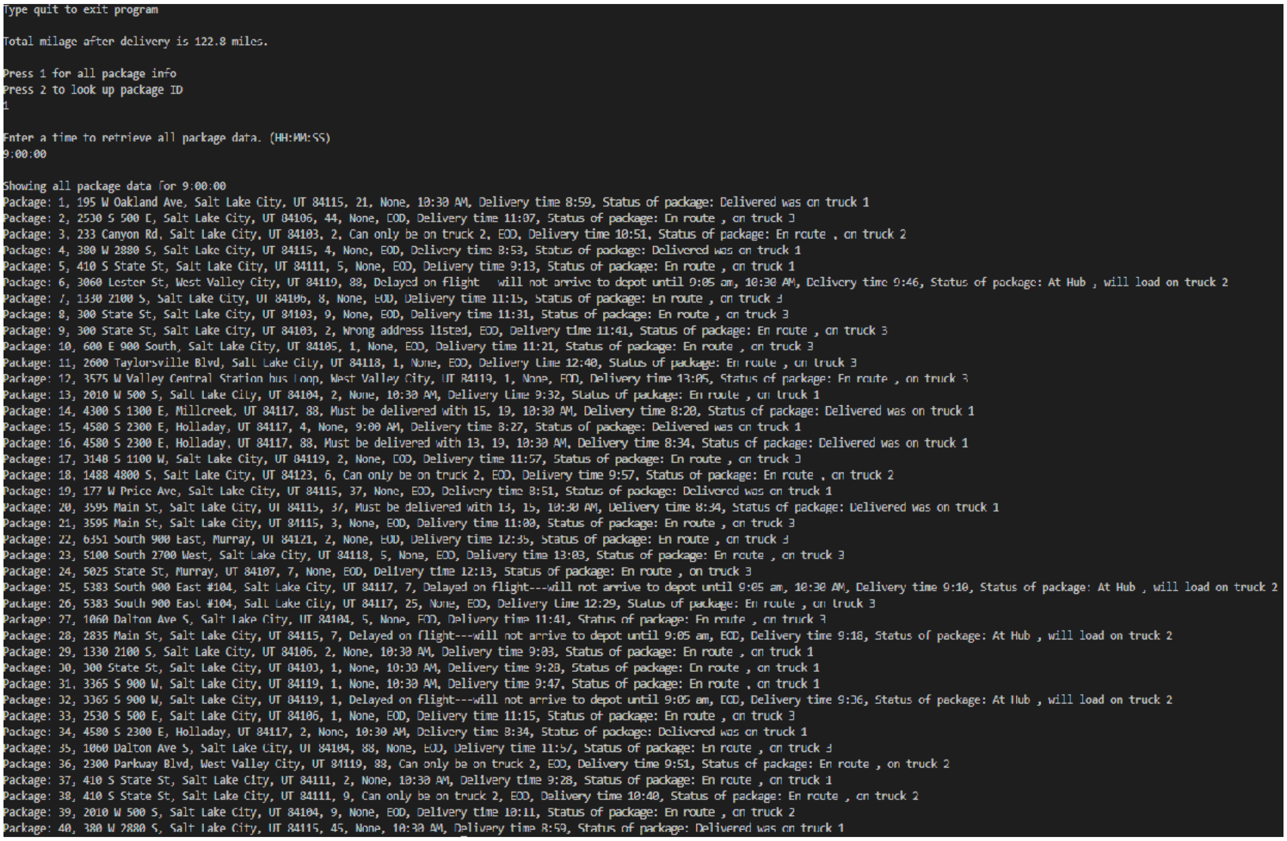
The Greedy algorithm will use the key in order to retrieve and compare the package to make deliveries. First the hash table will insert the package data for all packages in the truck and encapsulate the data in a package object. When a search function is run to retrieve a key (package ID), the search will return a pair (package as an object) which will contain the data for the specific package such as the address. The algorithm will loop by retrieving packages from the hash table and compare address data until the truck has made all its deliveries.

G) **Provide an interface for the user to view the status and info (as listed in part F) of any package at any time, and the total mileage traveled by all trucks. (The delivery status should report the package as at the hub, en route, or delivered. Delivery status must include the time.)**

All screenshots can be found in screenshot folder for better resolution

G1) Provide screenshots to show the status of all packages at a time between 8:35 a.m. and 9:25 a.m.

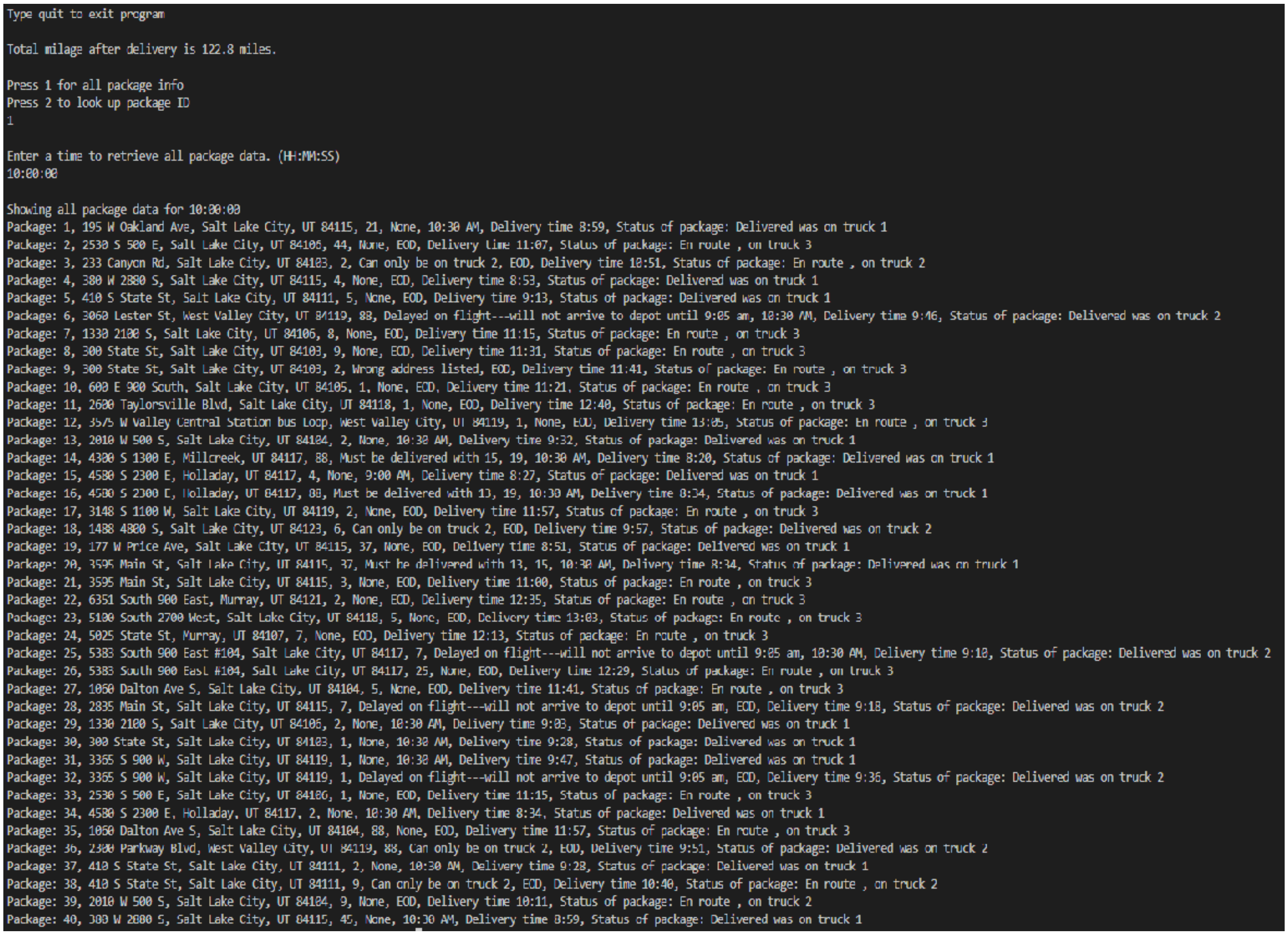
All package information for 9:00 a.m



```
Type quit to exit program

Total milage after delivery is 122.8 miles.

Press 1 for all package info
Press 2 to look up package ID
1

Enter a time to retrieve all package data. (HH:MM:SS)
9:00:00

Showing all package data for 9:00:00
Package: 1, 195 W Oakland Ave, Salt Lake City, UT 84115, 21, None, 10:30 AM, Delivery time 8:59, Status of package: Delivered was on truck 1
Package: 2, 2530 S 500 E, Salt Lake City, UT 84106, 44, None, EOD, Delivery time 11:07, Status of package: En route , on truck 3
Package: 3, 233 Canyon Rd, Salt Lake City, UT 84103, 2, Can only be on truck 2, EOD, Delivery time 10:51, Status of package: En route , on truck 2
Package: 4, 380 W 2880 S, Salt Lake City, UT 84115, 4, None, EOD, Delivery time 8:53, Status of package: Delivered was on truck 1
Package: 5, 410 S State St, Salt Lake City, UT 84111, 5, None, EOD, Delivery time 9:13, Status of package: En route , on truck 1
Package: 6, 3060 Lester St, West Valley City, UT 84119, 88, Delayed on flight   will not arrive to depot until 9:05 am, 10:30 AM, Delivery time 9:46, Status of package: At Hub , will load on truck 2
Package: 7, 1330 2100 S, Salt Lake City, UT 84106, 8, None, EOD, Delivery time 11:15, Status of package: En route , on truck 3
Package: 8, 300 State St, Salt Lake City, UT 84103, 9, None, EOD, Delivery time 11:31, Status of package: En route , on truck 3
Package: 9, 300 State St, Salt Lake City, UT 84103, 2, Wrong address listed, EOD, Delivery time 11:41, Status of package: En route , on truck 3
Package: 10, 600 E 900 South, Salt Lake City, UT 84105, 1, None, EOD, Delivery time 11:21, Status of package: En route , on truck 3
Package: 11, 2600 Taylorsville Blvd, Salt Lake City, UT 84118, 1, None, EOD, Delivery time 12:40, Status of package: En route , on truck 3
Package: 12, 3575 W Valley Central Station bus Loop, West Valley City, UT 84119, 1, None, EOD, Delivery time 13:05, Status of package: En route , on truck 3
Package: 13, 2010 W 500 S, Salt Lake City, UT 84104, 2, None, 10:30 AM, Delivery time 9:32, Status of package: En route , on truck 1
Package: 14, 4300 S 1300 E, Millcreek, UT 84117, 88, Must be delivered with 15, 19, 10:30 AM, Delivery time 8:20, Status of package: Delivered was on truck 1
Package: 15, 4580 S 2300 E, Holladay, UT 84117, 4, None, 9:00 AM, Delivery time 8:27, Status of package: Delivered was on truck 1
Package: 16, 4580 S 2300 E, Holladay, UT 84117, 88, Must be delivered with 13, 19, 10:30 AM, Delivery time 8:34, Status of package: Delivered was on truck 1
Package: 17, 3148 S 1100 W, Salt Lake City, UT 84119, 2, None, EOD, Delivery time 11:57, Status of package: En route , on truck 3
Package: 18, 1488 4800 S, Salt Lake City, UT 84123, 6, Can only be on truck 2, EOD, Delivery time 9:57, Status of package: En route , on truck 2
Package: 19, 177 W Price Ave, Salt Lake City, UT 84115, 37, None, EOD, Delivery time 8:51, Status of package: Delivered was on truck 1
Package: 20, 3595 Main St, Salt Lake City, UT 84115, 37, Must be delivered with 13, 15, 10:30 AM, Delivery time 8:34, Status of package: Delivered was on truck 1
Package: 21, 3595 Main St, Salt Lake City, UT 84115, 3, None, EOD, Delivery time 11:00, Status of package: En route , on truck 3
Package: 22, 6351 South 900 East, Murray, UT 84121, 2, None, EOD, Delivery time 12:35, Status of package: En route , on truck 3
Package: 23, 5100 South 2700 West, Salt Lake City, UT 84118, 5, None, EOD, Delivery time 13:03, Status of package: En route , on truck 3
Package: 24, 5025 State St, Murray, UT 84107, 7, None, EOD, Delivery time 12:13, Status of package: En route , on truck 3
Package: 25, 5383 South 900 East #104, Salt Lake City, UT 84117, 7, Delayed on flight---will not arrive to depot until 9:05 am, 10:30 AM, Delivery time 9:10, Status of package: At Hub , will load on truck 2
Package: 26, 5383 South 900 East #104, Salt Lake City, UT 84117, 25, None, EOD, Delivery time 12:29, Status of package: En route , on truck 3
Package: 27, 1060 Dalton Ave S, Salt Lake City, UT 84104, 5, None, EOD, Delivery time 11:41, Status of package: En route , on truck 3
Package: 28, 2835 Main St, Salt Lake City, UT 84115, 7, Delayed on flight---will not arrive to depot until 9:05 am, EOD, Delivery time 9:18, Status of package: At Hub , will load on truck 2
Package: 29, 1330 2100 S, Salt Lake City, UT 84106, 2, None, 10:30 AM, Delivery time 9:03, Status of package: En route , on truck 1
Package: 30, 300 State St, Salt Lake City, UT 84103, 1, None, 10:30 AM, Delivery time 9:28, Status of package: En route , on truck 1
Package: 31, 3365 S 900 W, Salt Lake City, UT 84119, 1, None, 10:30 AM, Delivery time 9:47, Status of package: En route , on truck 1
Package: 32, 3365 S 900 W, Salt Lake City, UT 84119, 1, Delayed on flight---will not arrive to depot until 9:05 am, EOD, Delivery time 9:36, Status of package: At Hub , will load on truck 2
Package: 33, 2530 S 500 E, Salt Lake City, UT 84106, 1, None, EOD, Delivery time 11:15, Status of package: En route , on truck 3
Package: 34, 4580 S 2300 E, Holladay, UT 84117, 2, None, 10:30 AM, Delivery time 8:34, Status of package: Delivered was on truck 1
Package: 35, 1060 Dalton Ave S, Salt Lake City, UT 84104, 88, None, EOD, Delivery time 11:57, Status of package: En route , on truck 3
Package: 36, 2300 Parkway Blvd, West Valley City, UT 84119, 88, Can only be on truck 2, EOD, Delivery time 9:51, Status of package: En route , on truck 2
Package: 37, 410 S State St, Salt Lake City, UT 84111, 2, None, 10:30 AM, Delivery time 9:28, Status of package: En route , on truck 1
Package: 38, 410 S State St, Salt Lake City, UT 84111, 9, Can only be on truck 2, EOD, Delivery time 10:40, Status of package: En route , on truck 2
Package: 39, 2010 W 500 S, Salt Lake City, UT 84104, 9, None, EOD, Delivery time 10:11, Status of package: En route , on truck 2
Package: 40, 380 W 2880 S, Salt Lake City, UT 84115, 45, None, 10:30 AM, Delivery time 8:59, Status of package: Delivered was on truck 1
```

G2) Provide screenshots to show the status of all packages at a time between 9:35 a.m. and 10:25 a.m.

All package information for 10:00 a.m



```
Type quit to exit program

Total milage after delivery is 122.8 miles.

Press 1 for all package info
Press 2 to look up package ID
1

Enter a time to retrieve all package data. (HH:MM:SS)
10:00:00

Showing all package data for 10:00:00
Package: 1, 195 W Oakland Ave, Salt Lake City, UT 84115, 21, None, 10:30 AM, Delivery time 8:59, Status of package: Delivered was on truck 1
Package: 2, 2530 S 500 E, Salt Lake City, UT 84106, 44, None, EOD, Delivery time 11:07, Status of package: En route , on truck 3
Package: 3, 233 Canyon Rd, Salt Lake City, UT 84103, 2, Can only be on truck 2, EOD, Delivery time 10:51, Status of package: En route , on truck 2
Package: 4, 380 W 2880 S, Salt Lake City, UT 84115, 4, None, EOD, Delivery time 8:53, Status of package: Delivered was on truck 1
Package: 5, 410 S State St, Salt Lake City, UT 84111, 5, None, EOD, Delivery time 9:13, Status of package: Delivered was on truck 1
Package: 6, 3060 Lester St, West Valley City, UT 84119, 88, Delayed on flight---will not arrive to depot until 9:05 am, 10:30 AM, Delivery time 9:46, Status of package: Delivered was on truck 2
Package: 7, 1330 2100 S, Salt Lake City, UT 84106, 8, None, EOD, Delivery time 11:15, Status of package: En route , on truck 3
Package: 8, 300 State St, Salt Lake City, UT 84103, 9, None, EOD, Delivery time 11:31, Status of package: En route , on truck 3
Package: 9, 300 State St, Salt Lake City, UT 84103, 2, Wrong address listed, EOD, Delivery time 11:41, Status of package: En route , on truck 3
Package: 10, 600 E 900 South, Salt Lake City, UT 84105, 1, None, EOD, Delivery time 11:21, Status of package: En route , on truck 3
Package: 11, 2600 Taylorsville Blvd, Salt Lake City, UT 84118, 1, None, EOD, Delivery time 12:40, Status of package: En route , on truck 3
Package: 12, 3575 W Valley Central Station bus Loop, West Valley City, UT 84119, 1, None, EOD, Delivery time 13:05, Status of package: En route , on truck 3
Package: 13, 2010 W 500 S, Salt Lake City, UT 84104, 2, None, 10:30 AM, Delivery time 9:32, Status of package: Delivered was on truck 1
Package: 14, 4300 S 1300 E, Millcreek, UT 84117, 88, Must be delivered with 15, 19, 10:30 AM, Delivery time 8:20, Status of package: Delivered was on truck 1
Package: 15, 4580 S 2300 E, Holladay, UT 84117, 4, None, 9:00 AM, Delivery time 8:27, Status of package: Delivered was on truck 1
Package: 16, 4580 S 2300 E, Holladay, UT 84117, 88, Must be delivered with 13, 19, 10:30 AM, Delivery time 8:34, Status of package: Delivered was on truck 1
Package: 17, 3148 S 1100 W, Salt Lake City, UT 84119, 2, None, EOD, Delivery time 11:57, Status of package: En route , on truck 3
Package: 18, 1488 4800 S, Salt Lake City, UT 84123, 6, Can only be on truck 2, EOD, Delivery time 9:57, Status of package: Delivered was on truck 2
Package: 19, 177 W Price Ave, Salt Lake City, UT 84115, 37, None, EOD, Delivery time 8:51, Status of package: Delivered was on truck 1
Package: 20, 3595 Main St, Salt Lake City, UT 84115, 37, Must be delivered with 13, 15, 10:30 AM, Delivery time 8:34, Status of package: Delivered was on truck 1
Package: 21, 3595 Main St, Salt Lake City, UT 84115, 3, None, EOD, Delivery time 11:00, Status of package: En route , on truck 3
Package: 22, 6351 South 900 East, Murray, UT 84121, 2, None, EOD, Delivery time 12:35, Status of package: En route , on truck 3
Package: 23, 5100 South 2700 West, Salt Lake City, UT 84118, 5, None, EOD, Delivery time 13:03, Status of package: En route , on truck 3
Package: 24, 5025 State St, Murray, UT 84107, 7, None, EOD, Delivery time 12:13, Status of package: En route , on truck 3
Package: 25, 5383 South 900 East #104, Salt Lake City, UT 84117, 7, Delayed on flight---will not arrive to depot until 9:05 am, 10:30 AM, Delivery time 9:10, Status of package: Delivered was on truck 2
Package: 26, 5383 South 900 East #104, Salt Lake City, UT 84117, 25, None, EOD, Delivery time 12:29, Status of package: En route , on truck 3
Package: 27, 1060 Dalton Ave S, Salt Lake City, UT 84104, 5, None, EOD, Delivery time 11:41, Status of package: En route , on truck 3
Package: 28, 2835 Main St, Salt Lake City, UT 84115, 7, Delayed on flight---will not arrive to depot until 9:05 am, EOD, Delivery time 9:18, Status of package: Delivered was on truck 2
Package: 29, 1330 2100 S, Salt Lake City, UT 84106, 2, None, 10:30 AM, Delivery time 9:03, Status of package: Delivered was on truck 1
Package: 30, 300 State St, Salt Lake City, UT 84103, 1, None, 10:30 AM, Delivery time 9:28, Status of package: Delivered was on truck 1
Package: 31, 3365 S 900 W, Salt Lake City, UT 84119, 1, None, 10:30 AM, Delivery time 9:47, Status of package: Delivered was on truck 1
Package: 32, 3365 S 900 W, Salt Lake City, UT 84119, 1, Delayed on flight---will not arrive to depot until 9:05 am, EOD, Delivery time 9:36, Status of package: Delivered was on truck 2
Package: 33, 2530 S 500 E, Salt Lake City, UT 84106, 1, None, EOD, Delivery time 11:15, Status of package: En route , on truck 3
Package: 34, 4580 S 2300 E, Holladay, UT 84117, 2, None, 10:30 AM, Delivery time 8:34, Status of package: Delivered was on truck 1
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Package: 36, 2300 Parkway Blvd, West Valley City, UT 84119, 88, Can only be on truck 2, EOD, Delivery time 9:51, Status of package: Delivered was on truck 2
Package: 37, 410 S State St, Salt Lake City, UT 84111, 2, None, 10:30 AM, Delivery time 9:28, Status of package: Delivered was on truck 1
Package: 38, 410 S State St, Salt Lake City, UT 84111, 9, Can only be on truck 2, EOD, Delivery time 10:40, Status of package: En route , on truck 2
Package: 39, 2010 W 500 S, Salt Lake City, UT 84104, 9, None, EOD, Delivery time 10:11, Status of package: En route , on truck 2
Package: 40, 380 W 2880 S, Salt Lake City, UT 84115, 45, None, 10:30 AM, Delivery time 8:59, Status of package: Delivered was on truck 1
```
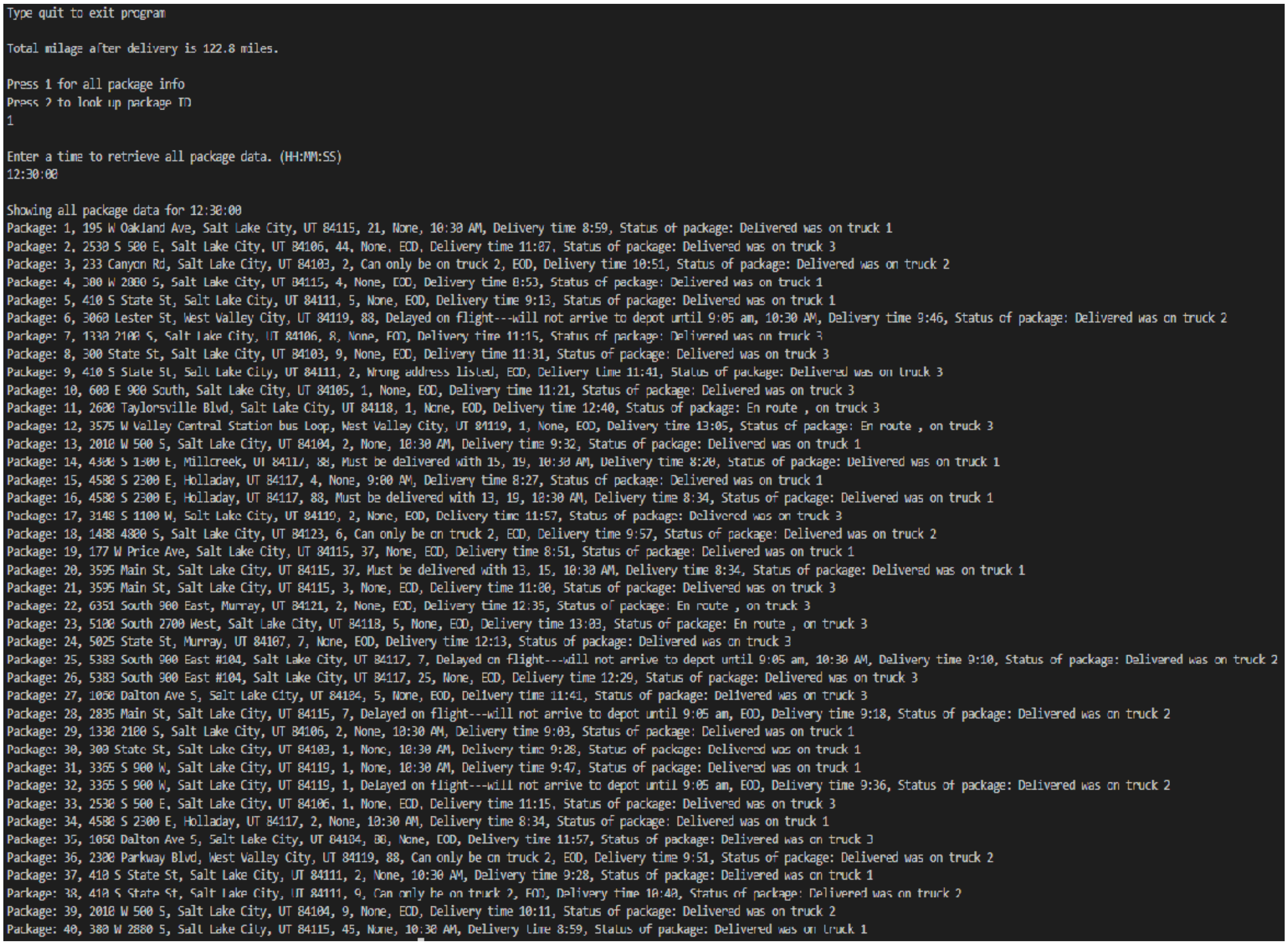

G3) Provide screenshots to show the status of all packages at a time between 12:03 p.m. and 1:12 p.m.

All package information for 12:30 p.m



```
Type quit to exit program

Total milage after delivery is 122.8 miles.

Press 1 for all package info
Press 2 to look up package ID
1

Enter a time to retrieve all package data. (HH:MM:SS)
12:30:00

Showing all package data for 12:30:00
Package: 1, 195 W Oakland Ave, Salt Lake City, UT 84115, 21, None, 10:30 AM, Delivery time 8:59, Status of package: Delivered was on truck 1
Package: 2, 2530 S 500 E, Salt Lake City, UT 84106, 44, None, EOD, Delivery time 11:07, Status of package: Delivered was on truck 3
Package: 3, 233 Canyon Rd, Salt Lake City, UT 84103, 2, Can only be on truck 2, EOD, Delivery time 10:51, Status of package: Delivered was on truck 2
Package: 4, 380 W 2880 S, Salt Lake City, UT 84115, 4, None, EOD, Delivery time 8:53, Status of package: Delivered was on truck 1
Package: 5, 410 S State St, Salt Lake City, UT 84111, 5, None, EOD, Delivery time 9:13, Status of package: Delivered was on truck 1
Package: 6, 3060 Lester St, West Valley City, UT 84119, 88, Delayed on flight---will not arrive to depot until 9:05 am, 10:30 AM, Delivery time 9:46, Status of package: Delivered was on truck 2
Package: 7, 1330 2100 S, Salt Lake City, UT 84106, 8, None, EOD, Delivery time 11:15, Status of package: Delivered was on truck 3
Package: 8, 300 State St, Salt Lake City, UT 84103, 9, None, EOD, Delivery time 11:31, Status of package: Delivered was on truck 3
Package: 9, 410 S State St, Salt Lake City, UT 84111, 2, Wrong address listed, EOD, Delivery time 11:41, Status of package: Delivered was on truck 3
Package: 10, 600 E 900 South, Salt Lake City, UT 84105, 1, None, EOD, Delivery time 11:21, Status of package: Delivered was on truck 3
Package: 11, 2600 Taylorsville Blvd, Salt Lake City, UT 84118, 1, None, EOD, Delivery time 12:40, Status of package: En route , on truck 3
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Package: 15, 4580 S 2300 E, Holladay, UT 84117, 4, None, 9:00 AM, Delivery time 8:27, Status of package: Delivered was on truck 1
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Package: 24, 5025 State St, Murray, UT 84107, 7, None, EOD, Delivery time 12:13, Status of package: Delivered was on truck 3
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Package: 33, 2530 S 500 E, Salt Lake City, UT 84106, 1, None, EOD, Delivery time 11:15, Status of package: Delivered was on truck 3
Package: 34, 4580 S 2300 E, Holladay, UT 84117, 2, None, 10:30 AM, Delivery time 8:34, Status of package: Delivered was on truck 1
Package: 35, 1060 Dalton Ave S, Salt Lake City, UT 84104, 88, None, EOD, Delivery time 11:57, Status of package: Delivered was on truck 3
Package: 36, 2300 Parkway Blvd, West Valley City, UT 84119, 88, Can only be on truck 2, EOD, Delivery time 9:51, Status of package: Delivered was on truck 2
Package: 37, 410 S State St, Salt Lake City, UT 84111, 2, None, 10:30 AM, Delivery time 9:28, Status of package: Delivered was on truck 1
Package: 38, 410 S State St, Salt Lake City, UT 84111, 9, Can only be on truck 2, EOD, Delivery time 10:40, Status of package: Delivered was on truck 2
Package: 39, 2010 W 500 S, Salt Lake City, UT 84104, 9, None, EOD, Delivery time 10:11, Status of package: Delivered was on truck 2
Package: 40, 380 W 2880 S, Salt Lake City, UT 84115, 45, None, 10:30 AM, Delivery time 8:59, Status of package: Delivered was on truck 1
```
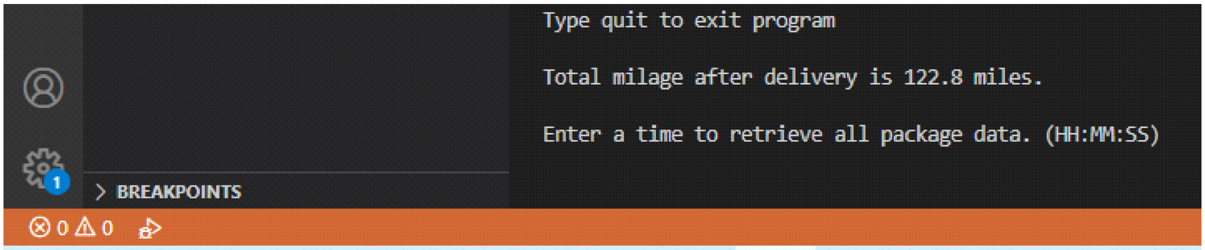

H) Provide a screenshot or screenshots showing successful completion of the code, free from runtime errors or warnings, that includes the total mileage traveled by all trucks.

Program UI asking for time to retrieve packages and total miles traveled by trucks with 0 errors and 0 warnings.



```
Type quit to exit program

Total milage after delivery is 122.8 miles.

Enter a time to retrieve all package data. (HH:MM:SS)
```

I1) Describe at least two strengths of the algorithm used in the solution.

The first strength of the Greedy algorithm is its simplicity. The algorithm compares all the package's destination and distances to the current location. Then it will choose the next location based on the shortest distance to the current location and repeat until all packages are found. Since it follows the same procedure for every package in the truck we could chart the iterations if desired in order to understand how the algorithm makes its decisions. This is something other algorithms will not be able to do as easily such as a brute force algorithm which would make charting all its iterations nearly impossible.

The second strength of the Greedy algorithm is the ability to easily add new packages and trucks without the need to edit the algorithm. Since the algorithm only takes in the truck number as a parameter there is no need to specify how many packages to deliver if more are added. The algorithm will automatically read the packages in the truck and know how many times to loop through to finish deliveries.

I3) Identify two other named algorithms, different from the algorithm implemented in the solution, that would meet the requirements in the scenario. Describe how each algorithm identified in part I3 is different from the algorithm used in the solution.

Brute Force Algorithm - This algorithm will check every scenario possible in order to achieve the best possible outcome. Using Brute force in combination of loading packages we will have the program go through all possibilities of loading the truck and then all the possible routes each truck will take until finding the shortest solution. The difference between Brute force and Greedy is that greedy will only go through whatever scenario it is given at that time. Brute Force will attempt all possible scenarios resulting in the shortest time but also causing the program to take much longer to compute a delivery route. (Freecodecamp, 2022)

Nearest Neighbor - This algorithm uses a weighted graph of nodes in order to find the shortest path between neighboring nodes. This would require making a graph of nodes , in this case the address, and use the distances as the weights between the nodes. This is similar to the algorithm but the difference here is that we did not map out all the addresses at once. Instead we only used the nodes from the current packages on each truck to find the distances. (Subramanian, Dhilip, 2021)

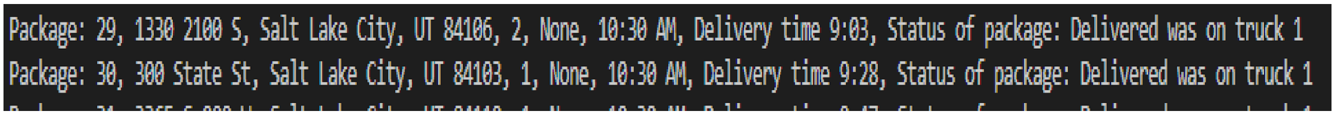
J) Describe what you would do differently, other than the two algorithms identified in I3, if you did this project again.

If I were to make this program again I would make a graph of nodes for my program and sort the packages to the trucks based on which packages are closest to each other. This would make the package sorting automatic and help if the amount of packages added is significant. By graphing all my addresses and sorting the packages based on the graph I can get better results with the algorithm currently in use or even switch to a nearest neighbor algorithm.

K1) Verify that the data structure used in the solution meets all requirements in the scenario.

The requirement of the data structure is to be able to store and manage data provided. This helps deliver the packages efficiently enough to be under 140 total miles traveled. We have been able to meet this requirement by only traveling 122.8 miles

The delivery time tracker has been edited and is now functioning as desired. Each package is delivered based on the time it takes to travel from one address to the other. Example packages 29 and 30 are each delivered by the same truck at the respective times based on the time of delivery.



```
Package: 29, 1330 2100 S, Salt Lake City, UT 84106, 2, None, 10:30 AM, Delivery time 9:03, Status of package: Delivered was on truck 1
Package: 30, 300 State St, Salt Lake City, UT 84103, 1, None, 10:30 AM, Delivery time 9:28, Status of package: Delivered was on truck 1
```

Fixed Packages on truck 2 to appear at hub until departure time.

a. Explain how the time needed to complete the look-up function is affected by changes in the number of packages to be delivered.

The hash table is an array of linked lists. When using the search function the list will look for the pair based on the key. Due to the nature of a linked list it must first travel through all indexes until the pair is found. If the amount of packages are increased by n then the amount of time taken to look up an item is increased by n. This gives the search function a time of 0(n).

b. Explain how the data structure space usage is affected by changes in the number of packages to be delivered.

The hash table stores items in indexes. If all indexes are full it will add more items to each index. As the amount of items is increased the amount of items per index is increased. This will cause the delivery and run time to slow down as more packages are needed to be delivered.

This means as more packages are added the amount of memory required will increase linearly. Since the hash table will have to expand its indexes for each new package added, the amount of memory used by python to store that package in the array will have to be allocated.

c. Describe how changes to the number of trucks or the number of cities would affect the look-up time and the space usage of the data structure.

Due to the fact that the trucks are not stored in the hash table there should be no change in look up time for the program. The trucks are instead a separate list that stores the packages which are in the table. Similarly the cities are also not stored in the hash table. The cities are imported from a csv that will create its own list of addresses and cities. The look up time will not be affected by an increase of cities. However if new packages were introduced with information of these new cities added then the lookup time will increase due to having more distances to compare than before.

K2) **2. Identify two other data structures that could meet the same requirements in the scenario.**

Stack
Graph

a. Describe how each data structure identified in part K2 is different from the data structure used in the solution.

Stacks can work similarly to a hash table in which they can add an item such as a package and then use the pop function to remove a package as it is delivered. However the lookup functions of a stack when compared to a hash table are limited.

Graphs consist of nodes and edges. This would make a graph perfect for storing and retrieving information for the distances and address. The address would be stored as a node and the distance as a weight. This would make searching for the shortest path during delivery easier.

L) Acknowledge sources, using in-text citations and references, for content that is quoted, paraphrased, or summarized.

freeCodeCamp.org, Freecodecamp. "Brute Force Algorithms Explained." *FreeCodeCamp.org*, FreeCodeCamp.org, 20 June 2022, https://www.freecodecamp.org/news/brute-force-algorithms-explained/#:~:text=The%20time%20complexity%20of%20brute,take%20us%20n%20*%20m%20tries.

Subramanian, Dhilip. "A Simple Introduction to K-Nearest Neighbors Algorithm." *Medium*, Towards Data Science, 12 July 2021, https://towardsdatascience.com/a-simple-introduction-to-k-nearest-neighbors-algorithm-b3519ed98e.