C950 WGUPS Algorithm Overview

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C950 Data Structures and Algorithms II

Introduction

The Western Governors University Parcel Service assignment focuses on creating an optimized delivery network that takes on the task of delivering 40 packages under strict yet doable constraints. In three building blocks, we have our packet sorting functions, next over we have our greedy function that optimizes route linking and lastly we have our UI components that work with our package report module.

A. Algorithm Identification

This assignment uses the Nearest Neighbor algorithm that makes the determination to locate optimal routes for package distribution.

B1. Logic Comments

We have programmed a class function that initiates an empty list

```
Cap package limit.

Set hashtable array to zero.

      for each item in a range of ten

            append the item to the hashtable array.

numList(referenceItem, key)

      Set hash value to a response variable

      from constructor array hashtable assign response var to a variable
listnumber.
```

The getHashTable() method feeds through the scaffolding delivery truck arrivals by matching items in the above hashtable array.

```
numList(referenceItem, key)

for items in a range 1 - 41

      initialize search from getHashTable

      initialize hashtable from getHashtable.hotItem()
```

B2. Development Environment

Here we are using Python 3.10.0 on Visual Studio Code 1.64.2 on a MSI GE72mVR Apache Pro Windows x64 - i7 Core Intel.

All files were kept locally for confidentiality.

B3. Space-Time and Big-O

Total space-time complexity

for WGUPS by Gabriel Cornejo:

dataStruct.py – O(n)

+

extractor.py – O(1)

+

distances.py – O(n^2)

+

ui.py – O(n)

= O(n)+ O(1)+ O(n^2)+ O(n)

= O(n^2)

dataStrut.py	
Method	Time Complexity
constructor	O(n)
hotItem	O(n)
adjuster	O(n)
extractor	O(n)
CLS dataStruct	O(n)

extractor.py	
Method	Time Complexity
getHashTable	O(1)
getTruckList	O(1)
assignPacks	O(1)
getPacks	O(1)

distances.py	
Method	Time Complexity
getAddress	O(n)
getDistance	O(1)
getTime	O(n)
getFastRoute	O(n^2)

ui.py	
Method	Time Complexity
packStatus	O(1)
quitMsg	O(1)
numberSwitch	O(n)

B4. Scalability and Adaptability

WGUPS aims to overcome the NP programming problem that is pervasive in problems similar to the salesman problem. A prevalent thorn in these types of programming problems is as more components are introduced the exponentially larger the problem becomes, thus becoming more difficult to solve. However, not impossible, the more packages we introduce the more trucks that will be needed as a result.

B5. Software Efficiency and Maintainability

The WGUPS program, assembled using Python, where Python uses object-oriented programming principles for efficient maintainable code, allows for any software developer to maintain. This can be seen through the directory structure and documented functions for any developer to discern.

B6. Self-Adjusting Data Structures

Strengths: Our self-adjusting data structure comes in the form of a chaining hash table that comes with preventative measures to avoid collisions. Collisions are avoided by linked lists that keep expanding as more entries are entered.

Weakness: However, this can have adverse implications on runtime. Measuring negative effects is seen through run-time complexity functions.

C. Original Code

**Run main.py

D. Data Structure

This program uses a **linear probing hash table data structure** to avoid collisions utilizing key/value pairs.

D1. Explanation of Data Structure

Referencing Part B Section 6, WGUPS's data structure is dependent on a chaining hash table for storing data points. The data structure will expand its storage by utilizing linked lists. Taking a CRUD style approach our application can sift through the packages to locate our package of choice by using a unique key derived from our hash function.

G1. First Status Check

```
Welcome to the Courier Package Delivery System

Enter 'quit' at anytime to quit session.


For all packet data enter enter: 1
For individual packet data enter: 2
For truck data: 3
  1
Enter the time format as HH:MM:SS:
9:00:00
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
Pack id number: 1
Load time: 9:10:00
Status: 9:13:00

--------------------------------------------------------------------------------
Pack id number: 2
Load time: 11:00:00
Status: 11:06:00

--------------------------------------------------------------------------------
Pack id number: 3
Load time: 11:00:00
Status: 11:09:00

--------------------------------------------------------------------------------
Pack id number: 4
Load time: 11:00:00
Status: 11:05:00

--------------------------------------------------------------------------------
Pack id number: 5
Load time: 9:10:00
Status: 9:24:00

--------------------------------------------------------------------------------
Pack id number: 6
Load time: 8:00:00
Status: 8:13:00

--------------------------------------------------------------------------------
Pack id number: 7
Load time: 8:00:00
Status: 8:19:00

--------------------------------------------------------------------------------
Pack id number: 8
Load time: 11:00:00
Status: 11:02:00

--------------------------------------------------------------------------------
Pack id number: 9
Load time: 11:00:00
Status: 11:00:00

--------------------------------------------------------------------------------
Pack id number: 10
Load time: 11:00:00
Status: 11:11:00

--------------------------------------------------------------------------------
Pack id number: 11
Load time: 11:00:00
Status: 11:01:00

--------------------------------------------------------------------------------
Pack id number: 12
Load time: 8:00:00
Status: 8:05:00

--------------------------------------------------------------------------------
Pack id number: 13
Load time: 9:10:00
Status: 9:23:00

--------------------------------------------------------------------------------
Pack id number: 14
Load time: 9:10:00
Status: 9:16:00
```

```
--------------------------------------------------------------------------------
Pack id number: 15
Load time: 9:10:00
Status: 9:17:00

--------------------------------------------------------------------------------
Pack id number: 16
Load time: 9:10:00
Status: 9:10:00

--------------------------------------------------------------------------------
Pack id number: 17
Load time: 8:00:00
Status: 8:04:00

--------------------------------------------------------------------------------
Pack id number: 18
Load time: 9:10:00
Status: 9:39:00

--------------------------------------------------------------------------------
Pack id number: 19
Load time: 8:00:00
Status: 8:07:00

--------------------------------------------------------------------------------
Pack id number: 20
Load time: 9:10:00
Status: 9:23:00

--------------------------------------------------------------------------------
Pack id number: 21
Load time: 11:00:00
Status: 11:07:00

--------------------------------------------------------------------------------
Pack id number: 22
Load time: 11:00:00
Status: 11:10:00

--------------------------------------------------------------------------------
Pack id number: 23
Load time: 11:00:00
Status: 11:23:00

--------------------------------------------------------------------------------
Pack id number: 24
Load time: 11:00:00
Status: 11:14:00

--------------------------------------------------------------------------------
Pack id number: 25
Load time: 8:00:00
Status: 8:39:00

--------------------------------------------------------------------------------
Pack id number: 26
Load time: 9:10:00
Status: 9:21:00

--------------------------------------------------------------------------------
Pack id number: 27
Load time: 11:00:00
Status: 11:16:00

--------------------------------------------------------------------------------
Pack id number: 28
Load time: 9:10:00
Status: 9:14:00

--------------------------------------------------------------------------------
Pack id number: 29
Load time: 9:10:00
Status: 9:41:00

--------------------------------------------------------------------------------
Pack id number: 30
Load time: 9:10:00
Status: 9:13:00

--------------------------------------------------------------------------------
```

```
--------------------------------------------------------------------------------
Pack id number: 31
Load time: 8:00:00
Status: 8:02:00

--------------------------------------------------------------------------------
Pack id number: 32
Load time: 9:10:00
Status: 9:16:00

--------------------------------------------------------------------------------
Pack id number: 33
Load time: 11:00:00
Status: 11:00:00

--------------------------------------------------------------------------------
Pack id number: 34
Load time: 9:10:00
Status: 9:10:00

--------------------------------------------------------------------------------
Pack id number: 35
Load time: 11:00:00
Status: 11:00:00

--------------------------------------------------------------------------------
Pack id number: 36
Load time: 9:10:00
Status: 9:21:00

--------------------------------------------------------------------------------
Pack id number: 37
Load time: 9:10:00
Status: 9:10:00

--------------------------------------------------------------------------------
Pack id number: 38
Load time: 9:10:00
Status: 9:10:00

--------------------------------------------------------------------------------
Pack id number: 39
Load time: 8:00:00
Status: 8:29:00

--------------------------------------------------------------------------------
Pack id number: 40
Load time: 9:10:00
Status: 9:14:00
```

G2. Second Status Check

```
Welcome to the Courier Package Delivery System

Enter 'quit' at anytime to quit session.


For all packet data enter enter: 1
For individual packet data enter: 2
For truck data: 3
1
Enter the time format as HH:MM:SS:
10:00:00
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
Pack id number: 1
Load time: 9:10:00
Status: 9:13:00

--------------------------------------------------------------------------------
Pack id number: 2
Load time: 11:00:00
Status: 11:06:00

--------------------------------------------------------------------------------
Pack id number: 3
Load time: 11:00:00
Status: 11:09:00

--------------------------------------------------------------------------------
Pack id number: 4
Load time: 11:00:00
Status: 11:05:00

--------------------------------------------------------------------------------
Pack id number: 5
Load time: 9:10:00
Status: 9:24:00

--------------------------------------------------------------------------------
Pack id number: 6
Load time: 8:00:00
Status: 8:13:00

--------------------------------------------------------------------------------
Pack id number: 7
Load time: 8:00:00
Status: 8:19:00

--------------------------------------------------------------------------------
Pack id number: 8
Load time: 11:00:00
Status: 11:02:00

--------------------------------------------------------------------------------
Pack id number: 9
Load time: 11:00:00
Status: 11:00:00

--------------------------------------------------------------------------------
Pack id number: 10
Load time: 11:00:00
Status: 11:11:00

--------------------------------------------------------------------------------
Pack id number: 11
Load time: 11:00:00
Status: 11:01:00

--------------------------------------------------------------------------------
Pack id number: 12
Load time: 8:00:00
Status: 8:05:00

--------------------------------------------------------------------------------
Pack id number: 13
Load time: 9:10:00
Status: 9:23:00

--------------------------------------------------------------------------------
Pack id number: 14
Load time: 9:10:00
Status: 9:16:00
```

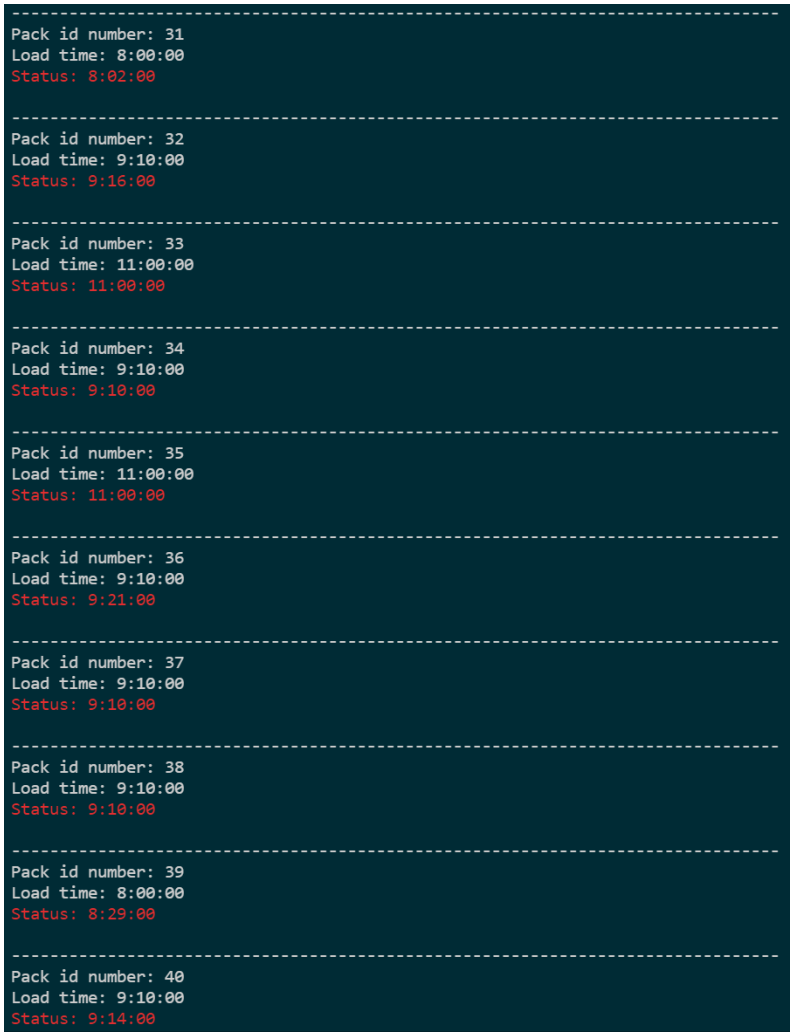
```
------------------------------------------------------------------------------
Pack id number: 15
Load time: 9:10:00
Status: 9:17:00

------------------------------------------------------------------------------
Pack id number: 16
Load time: 9:10:00
Status: 9:10:00

------------------------------------------------------------------------------
Pack id number: 17
Load time: 8:00:00
Status: 8:04:00

------------------------------------------------------------------------------
Pack id number: 18
Load time: 9:10:00
Status: 9:39:00

------------------------------------------------------------------------------
Pack id number: 19
Load time: 8:00:00
Status: 8:07:00

------------------------------------------------------------------------------
Pack id number: 20
Load time: 9:10:00
Status: 9:23:00

------------------------------------------------------------------------------
Pack id number: 21
Load time: 11:00:00
Status: 11:07:00

------------------------------------------------------------------------------
Pack id number: 22
Load time: 11:00:00
Status: 11:10:00

------------------------------------------------------------------------------
Pack id number: 23
Load time: 11:00:00
Status: 11:23:00

------------------------------------------------------------------------------
Pack id number: 24
Load time: 11:00:00
Status: 11:14:00

------------------------------------------------------------------------------
Pack id number: 25
Load time: 8:00:00
Status: 8:39:00

------------------------------------------------------------------------------
Pack id number: 26
Load time: 9:10:00
Status: 9:21:00

------------------------------------------------------------------------------
Pack id number: 27
Load time: 11:00:00
Status: 11:16:00

------------------------------------------------------------------------------
Pack id number: 28
Load time: 9:10:00
Status: 9:14:00

------------------------------------------------------------------------------
Pack id number: 29
Load time: 9:10:00
Status: 9:41:00

------------------------------------------------------------------------------
Pack id number: 30
Load time: 9:10:00
Status: 9:13:00
```

```
------------------------------------------------------------------------------
Pack id number: 31
Load time: 8:00:00
Status: 8:02:00

------------------------------------------------------------------------------
Pack id number: 32
Load time: 9:10:00
Status: 9:16:00

------------------------------------------------------------------------------
Pack id number: 33
Load time: 11:00:00
Status: 11:00:00

------------------------------------------------------------------------------
Pack id number: 34
Load time: 9:10:00
Status: 9:10:00

------------------------------------------------------------------------------
Pack id number: 35
Load time: 11:00:00
Status: 11:00:00

------------------------------------------------------------------------------
Pack id number: 36
Load time: 9:10:00
Status: 9:21:00

------------------------------------------------------------------------------
Pack id number: 37
Load time: 9:10:00
Status: 9:10:00

------------------------------------------------------------------------------
Pack id number: 38
Load time: 9:10:00
Status: 9:10:00

------------------------------------------------------------------------------
Pack id number: 39
Load time: 8:00:00
Status: 8:29:00

------------------------------------------------------------------------------
Pack id number: 40
Load time: 9:10:00
Status: 9:14:00
```

G3. Third Status Check

```
Welcome to the Courier Package Delivery System

Enter 'quit' at anytime to quit session.


For all packet data enter enter: 1
For individual packet data enter: 2
For truck data: 3
  1
Enter the time format as HH:MM:SS:
12:40:00
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
Pack id number: 1
Load time: 9:10:00
Status: 9:13:00

--------------------------------------------------------------------------------
Pack id number: 2
Load time: 11:00:00
Status: 11:06:00

--------------------------------------------------------------------------------
Pack id number: 3
Load time: 11:00:00
Status: 11:09:00

--------------------------------------------------------------------------------
Pack id number: 4
Load time: 11:00:00
Status: 11:05:00

--------------------------------------------------------------------------------
Pack id number: 5
Load time: 9:10:00
Status: 9:24:00

--------------------------------------------------------------------------------
Pack id number: 6
Load time: 8:00:00
Status: 8:13:00

--------------------------------------------------------------------------------
Pack id number: 7
Load time: 8:00:00
Status: 8:19:00

--------------------------------------------------------------------------------
Pack id number: 8
Load time: 11:00:00
Status: 11:02:00

--------------------------------------------------------------------------------
Pack id number: 9
Load time: 11:00:00
Status: 11:00:00

--------------------------------------------------------------------------------
Pack id number: 10
Load time: 11:00:00
Status: 11:11:00

--------------------------------------------------------------------------------
Pack id number: 11
Load time: 11:00:00
Status: 11:01:00

--------------------------------------------------------------------------------
Pack id number: 12
Load time: 8:00:00
Status: 8:05:00

--------------------------------------------------------------------------------
Pack id number: 13
Load time: 9:10:00
Status: 9:23:00

--------------------------------------------------------------------------------
Pack id number: 14
Load time: 9:10:00
Status: 9:16:00
```

```
--------------------------------------------------------------------------------
Pack id number: 15
Load time: 9:10:00
Status: 9:17:00

--------------------------------------------------------------------------------
Pack id number: 16
Load time: 9:10:00
Status: 9:10:00

--------------------------------------------------------------------------------
Pack id number: 17
Load time: 8:00:00
Status: 8:04:00

--------------------------------------------------------------------------------
Pack id number: 18
Load time: 9:10:00
Status: 9:39:00

--------------------------------------------------------------------------------
Pack id number: 19
Load time: 8:00:00
Status: 8:07:00

--------------------------------------------------------------------------------
Pack id number: 20
Load time: 9:10:00
Status: 9:23:00

--------------------------------------------------------------------------------
Pack id number: 21
Load time: 11:00:00
Status: 11:07:00

--------------------------------------------------------------------------------
Pack id number: 22
Load time: 11:00:00
Status: 11:10:00

--------------------------------------------------------------------------------
Pack id number: 23
Load time: 11:00:00
Status: 11:23:00

--------------------------------------------------------------------------------
Pack id number: 24
Load time: 11:00:00
Status: 11:14:00

--------------------------------------------------------------------------------
Pack id number: 25
Load time: 8:00:00
Status: 8:39:00

--------------------------------------------------------------------------------
Pack id number: 26
Load time: 9:10:00
Status: 9:21:00

--------------------------------------------------------------------------------
Pack id number: 27
Load time: 11:00:00
Status: 11:16:00

--------------------------------------------------------------------------------
Pack id number: 28
Load time: 9:10:00
Status: 9:14:00

--------------------------------------------------------------------------------
Pack id number: 29
Load time: 9:10:00
Status: 9:41:00

--------------------------------------------------------------------------------
Pack id number: 30
Load time: 9:10:00
Status: 9:13:00

--------------------------------------------------------------------------------
```


Pack id number: 31
Load time: 8:00:00
Status: 8:02:00
Pack id number: 32
Load time: 9:10:00
Status: 9:16:00
Pack id number: 33
Load time: 11:00:00
Status: 11:00:00
Pack id number: 34
Load time: 9:10:00
Status: 9:10:00
Pack id number: 35
Load time: 11:00:00
Status: 11:00:00
Pack id number: 36
Load time: 9:10:00
Status: 9:21:00
Pack id number: 37
Load time: 9:10:00
Status: 9:10:00
Pack id number: 38
Load time: 9:10:00
Status: 9:10:00
Pack id number: 39
Load time: 8:00:00
Status: 8:29:00
Pack id number: 40
Load time: 9:10:00
Status: 9:14:00

H. Screenshots of Code Execution

```
Welcome to the Courier Package Delivery System

Enter 'quit' at anytime to quit session.


For all packet data enter enter: 1
For individual packet data enter: 2
For truck data: 3
  3
Truck 1: Total distance: 35.6
Truck 2: Total distance: 46.6
Truck 3: Total distance: 31.3
Total distance by all trucks: 113.5

Type quit to terminate the program

Hit the enter key to continue.
```

I1. Strengths of Chosen Algorithm

Simplicity: Our program derives much of its strength from its easy to use User Interface components created. Additionally, our program really aims to consume a minimum amount of storage space for scalability. This carries over to our program's other strength, that is adaptability.

Adaptability: What makes our program very adaptable is its neatly packaged ui module where changes come from a centralized source.

I2. Verification of Algorithm

All our packages arrived on time with given constraints. The total mileage of all trucks totals to 113.5 miles. Below is an image that shows the three truck distances.

```
Truck 1: Total distance: 35.6
Truck 2: Total distance: 46.6
Truck 3: Total distance: 31.3
Total distance by all trucks: 113.5

Type quit to terminate the program

Hit the enter key to continue.
```

I3. Other possible Algorithms

Other possible algorithms are **Simulated Annealing** and another widely known algorithm, the **Genetic algorithm** traveling salesman.

I3A. Algorithm Differences

The **Simulated Annealing** derives its function from it's name which relates to techniques used in metallurgy. Moreover, the process starts by finding lower levels of energy for function cost. The cost function to the TSP is the minimization of the distance that needs to be traveled. In **Genetic TSP** we see that locations are treated as genes as they would in Genetic heuristic search algorithms.

J. Different Approach

Given the opportunity to redo this assignment I would focus on loading the items in a more concise manner. The reason for this is to avoid any boilerplate code pasted from one across modules. This would be used for scalability reasons. Keeping code central to a resolving class would solve this issue.

Another focus approach is changing our greedy function to more efficiently drive our distance table. This means focusing on trucks near to their location of travel.

K1. Verification of Data Structure

Our program uses a hash table that accepts, insert and lookup functions that work in tandem to search and store packages. The WGUPs app allows for insert and lookup functionality through the use of the implemented hashtable, in addition to allowing the user to display all statuses of packages at any time.

K1A. Efficiency

Our hashtable has a worst case time complexity of big O(n) that stems from parameter constraints placed on the program. So when adding the data to the hashtable a large number of entries our hashtable must limit the number of items to avoid collisions.

K1B. Overhead

Overhead comes from the large number of items that need to be compared in our hashtable. Our table will double in size when about half storage capacity is reached.

K1C. Implications

Adding more items will not increase search time. This is due to limiting the number which will prevent our hashtable from expande our table from rehashing.

K2. Other Data Structures

Two other data structures are (1) Stack and (2) a hash table using an array of linked lists.

K2a. Data Structure Differences

Hashing table of linked list:

Mapping: With a hashing table of linked list requires no resizing of hash table as items are added to the linked list.

Cons or weakness: Here we are dependent on an array storing the data that is pointed to by a separate array holding hash values.

Stacks:

Mapping: Stacks represent a more simple data structure where data can easily be retrieved from any instance, for example if we wanted to retrieve data from a solo truck.

Cons or weakness: Stacks can quickly become cumbersome when a program introduces more constraints. Although, under experimental measures stacks work perfectly fine as they are more storage-efficient.

When comparing chaining hash tables to a stack data structure or a hashing table of linked lists we have to be aware that in hashing tables of linked lists we are dependent on storing in arrays that are linked by another separate array, whereas stacks can become difficult to manage for larger lists of objects. When compared to the data structure used in our program, that is a chaining hash table, we see that chaining hash tables allow for the best flexibility due to their key/value pairs the other two data structures introduced here.

L. Sources - Works Cited

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