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Core Algorithm Overview

Stated Problem:

The purpose of this project is to create an algorithm using the Python programming language to develop an effective and efficient solution for the traveling salesman problem (TSP) which Wikipedia defines as the following question: "Given a list of cities and the distances between each pair of cities, what is the shortest possible route that visits each city exactly once and returns to the origin city?" [1] .

This assignment adds additional requirements of:

- Package delivery deadlines
- Packages which must be on the same truck
- Packages which must be on a specific truck
- Truck load limitation
- Truck speed constraint
- 2 Trucks can be operational at one time.
- One package has the wrong address assigned and must be fixed at 10:20am

Program Blueprint and Architecture:

Classes:

- csv_import: imports all the data from the csv's provided
- Config: Contains all the global variables for the application
- Truck: represents a single truck which follows a route.
- Route: Represents an ordered collection of deliveries and locations
- Delivery: Represents a collection of Packages which are delivered to the same location
- Location: a single point in a Route which has a name, address, city, state, zip.
- Package: The smallest unit to deliver which is imported from the packages.csv file.
- CLI: The Command line Interface which presents the user with options and reports
- Debug: functions which print out reports for Trucks, Deliveries, Routes, Packages
- Distance: A class which calculates the distances of routes and between two deliveries/locations.
- HashTable: A custom hash map class which is used instead of the python dictionary.

Algorithm Overview:

The proposed solution for this assignment uses a **brute force** method which tried to insert a delivery into each index within the route. Determining the miles which would be added to the route at a particular index. The method will return the route and the index which would cause the route to increase in the least number of miles possible which adhering to the deadlines of the packages within a delivery.

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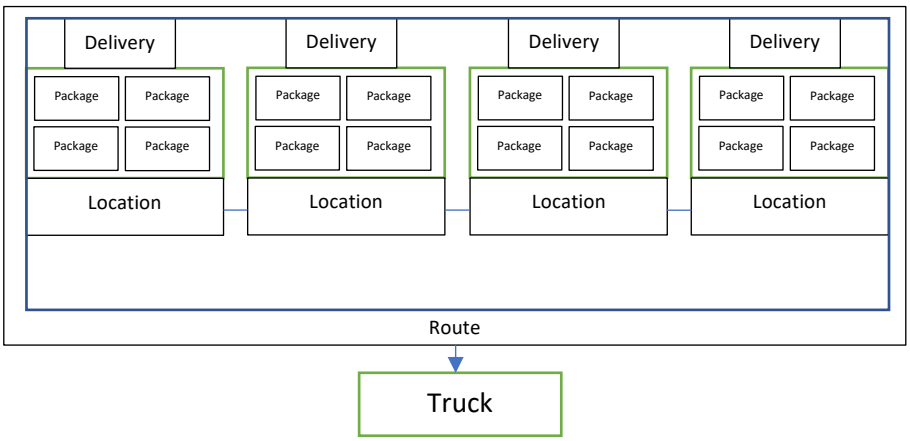
[1] Traveling Salesman Problem. (2020) wikipedia.org
https://en.wikipedia.org/wiki/Travelling_salesman_problem

Relationship between data points stored



Deliveries are composed of Packages grouped by locations.
Routes is a list of Deliveries with a sorted list of Locations to follow through the route.
Each Truck is assigned a Route.

Logic of Algorithm Applied

The **distribute_deliveries_to_trucks** and the **added_distance** function within the route class performs this procedure with the following pseudocode.

distribute_deliveries_to_trucks (Big O(n^2))**:**

> **first assigns any deliveries which must be assigned to truck 2.**
> **Retrieve the remaining deliveries with unassigned trucks.**
> **Define the time during when a particular truck will depart the depot (starting point)**
> **Loop through each Delivery and call the added_distance method for each truck**
> **Calculate the best truck and best route index for a given delivery.**
> **Check the delivery ETA is before the deadline and return the Route index or None.**
> **Assign the delivery to the truck with the least added distance**.

Repeat this loop until all deliveries are assigned to a truck.

Handling Constraints:

1. **Package delivery deadlines**
   The **added_distance** function will check to make sure all packages arrive to destination before deadline when returning a route and index
   If no options were found to meet these criteria None will be returned.
2. **Packages which must be on a specific truck and Packages which must be on the same truck**
   The **distribute_deliveries_to_trucks** method first assigns any deliveries which have packages with assignment constraints
3. **Truck speed constraint**
   The Truck class has a property of **max_speed** which is used to calculate how many miles were traveling during a specified time frame.

4. **Truck load limitation**
   The Truck class has a **will_fit** method which calculates to see if a truck has enough space for a delivery before doing any additional assertions and calculations.
5. **Two Trucks at one time.**
   The main program loop will check to see if a truck has completed its' route and it is past 10:20am.
   Then it will dispatch Truck 3 and start its route.
6. **Handling the wrong address constraint:**
   Keep Package 9 unassigned since the address is incorrect, assign it to Truck 3 when the correct address is available (10:20 am)

Adaptability to a changing market

This application has some flexibility in adjusting to more packages up to the point that another truck is needed.

Scalability

If the user were to need additional trucks another truck can be easily added and dispatched.
CSV Files can be easily loaded with more data.

Efficiency and maintainability of the software.

The application is split into logical files which individually handle each aspect of the structure of the application. Each method is commented to be able to easily follow the lifecycle of the application.
In order to make changes and make sure the results are as expected the future developer can rely on the Debug Class to output a printed table of all the data structures within the application at any given time using the CLI

Self-adjusting data structures chosen

The Hash Table Class implements a simple hash key taking into account the sum of the Unicode code point value for each character in the key's string modulo into the hash Table's size[2].
The default value for the size of the HashTable Class is 128 but it can be adjusted.
Magic Methods have been implemented to make interaction with the HashTable class simpler to iterate with and check if it contains a value.

Strengths of the chosen algorithm

1. Having a Brute Force algorithm makes sure all options are taken into account and evaluated to select the most efficient route.
2. Having a simple algorithm such as Brute force for a small sample of packages and possible routes makes the program simpler to test.

[2] Lysecky, R., & Vahid, F. (2018). C950: Data Structures and Algorithms Ii. zyBook.

Different Approach

This program is not scalable to many packages as is 2-opt or Dijkstra's[3] algorithms.
The Trucks are explicitly defined so any changes to the trucks would need to be defined explicitly.
A different approach would make the program loop the array and not call each truck explicitly

Screen Shots

Screenshots of Code Execution: CLI Options presented to user.

```
-- Menu --
Enter the Letter for the report you would like to generate:
enter a number of minutes you would like to simulate has passed e.g 15, 60 (1 hr), 120 (2 hr).
    P Packages
    D Deliveries
    R Route
    T trucks
    Q return to main menu
enter an option: p
```

[3] Nilsson, C. (2003). Heuristics for the traveling salesman problem. Linkoping University.

First Status Check 9:30am

_____PACKAGES_____

id	Address	Truck	Deadline	Notes	Time Delivere
1	195 W Oakland Ave	1	10:30 AM	N/A	08:22:00
2	2530 S 500 E	3	17:00 PM	N/A	undelivered
3	233 Canyon Rd	2	17:00 PM	truck 2	08:54:20
4	380 W 2880 S	1	17:00 PM	N/A	08:25:40
5	410 S State St	2	17:00 PM	N/A	undelivered
6	3060 Lester St	1	10:30 AM	depart 9:05 am	08:41:20
7	1330 2100 S	1	17:00 PM	N/A	08:12:40
8	300 State St	1	17:00 PM	N/A	09:10:40
9	300 State St	unassigned	17:00 PM	Wrong address listed	undelivered
10	600 E 900 South	3	17:00 PM	N/A	undelivered
11	2600 Taylorsville Blvd	3	17:00 PM	N/A	undelivered
12	3575 W Valley Central Station bus Loop	3	17:00 PM	N/A	undelivered
13	2010 W 500 S	1	10:30 AM	N/A	08:56:40
14	4300 S 1300 E	2	10:30 AM	together 15;19	08:26:00
15	4580 S 2300 E	2	09:00 AM	N/A	08:19:20
16	4580 S 2300 E	2	10:30 AM	together 13;19	08:19:20
17	3148 S 1100 W	3	17:00 PM	N/A	undelivered
18	1488 4800 S	2	17:00 PM	truck 2	undelivered
19	177 W Price Ave	3	17:00 PM	N/A	undelivered
20	3595 Main St	1	10:30 AM	together 13;15	08:31:00
21	3595 Main St	1	17:00 PM	N/A	08:31:00
22	6351 South 900 East	3	17:00 PM	N/A	undelivered
23	5100 South 2700 West	3	17:00 PM	N/A	undelivered
24	5025 State St	3	17:00 PM	N/A	undelivered
25	5383 South 900 East #104	2	10:30 AM	depart 9:05 am	08:08:00
26	5383 South 900 East #104	2	17:00 PM	N/A	08:08:00
27	1060 Dalton Ave S	1	17:00 PM	N/A	08:51:20
28	2835 Main St	3	17:00 PM	depart 9:05 am	undelivered
29	1330 2100 S	1	10:30 AM	N/A	08:12:40
30	300 State St	1	10:30 AM	N/A	09:10:40
31	3365 S 900 W	1	10:30 AM	N/A	08:36:20
32	3365 S 900 W	1	17:00 PM	depart 9:05 am	08:36:20
33	2530 S 500 E	3	17:00 PM	N/A	undelivered
34	4580 S 2300 E	2	10:30 AM	N/A	08:19:20
35	1060 Dalton Ave S	1	17:00 PM	N/A	08:51:20
36	2300 Parkway Blvd	2	17:00 PM	truck 2	undelivered
37	410 S State St	2	10:30 AM	N/A	undelivered
38	410 S State St	2	17:00 PM	truck 2	undelivered
39	2010 W 500 S	1	17:00 PM	N/A	08:56:40
40	380 W 2880 S	1	10:30 AM	N/A	08:25:40

Second Status Check 10:20am

_____PACKAGES_____

id	Address	Truck	Deadline	Notes	Time Delivered
1	195 W Oakland Ave	1	10:30 AM	N/A	08:22:00
2	2530 S 500 E	3	17:00 PM	N/A	undelivered
3	233 Canyon Rd	2	17:00 PM	truck 2	08:54:20
4	380 W 2880 S	1	17:00 PM	N/A	08:25:40
5	410 S State St	2	17:00 PM	N/A	undelivered
6	3060 Lester St	1	10:30 AM	depart 9:05 am	08:41:20
7	1330 2100 S	1	17:00 PM	N/A	08:12:40
8	300 State St	1	17:00 PM	N/A	09:10:40
9	300 State St	unassigned	17:00 PM	Wrong address listed	undelivered
10	600 E 900 South	3	17:00 PM	N/A	undelivered
11	2600 Taylorsville Blvd	3	17:00 PM	N/A	undelivered
12	3575 W Valley Central Station bus Loop	3	17:00 PM	N/A	undelivered
13	2010 W 500 S	1	10:30 AM	N/A	08:56:40
14	4300 S 1300 E	2	10:30 AM	together 15;19	08:26:00
15	4580 S 2300 E	2	09:00 AM	N/A	08:19:20
16	4580 S 2300 E	2	10:30 AM	together 13;19	08:19:20
17	3148 S 1100 W	3	17:00 PM	N/A	undelivered
18	1488 4800 S	2	17:00 PM	truck 2	09:31:20
19	177 W Price Ave	3	17:00 PM	N/A	undelivered
20	3595 Main St	1	10:30 AM	together 13;15	08:31:00
21	3595 Main St	1	17:00 PM	N/A	08:31:00
22	6351 South 900 East	3	17:00 PM	N/A	undelivered
23	5100 South 2700 West	3	17:00 PM	N/A	undelivered
24	5025 State St	3	17:00 PM	N/A	undelivered
25	5383 South 900 East #104	2	10:30 AM	depart 9:05 am	08:08:00
26	5383 South 900 East #104	2	17:00 PM	N/A	08:08:00
27	1060 Dalton Ave S	1	17:00 PM	N/A	08:51:20
28	2835 Main St	3	17:00 PM	depart 9:05 am	undelivered
29	1330 2100 S	1	10:30 AM	N/A	08:12:40
30	300 State St	1	10:30 AM	N/A	09:10:40
31	3365 S 900 W	1	10:30 AM	N/A	08:36:20
32	3365 S 900 W	1	17:00 PM	depart 9:05 am	08:36:20
33	2530 S 500 E	3	17:00 PM	N/A	undelivered
34	4580 S 2300 E	2	10:30 AM	N/A	08:19:20
35	1060 Dalton Ave S	1	17:00 PM	N/A	08:51:20
36	2300 Parkway Blvd	2	17:00 PM	truck 2	09:44:40
37	410 S State St	2	10:30 AM	N/A	undelivered
38	410 S State St	2	17:00 PM	truck 2	undelivered
39	2010 W 500 S	1	17:00 PM	N/A	08:56:40
40	380 W 2880 S	1	10:30 AM	N/A	08:25:40

Third Status Check 1:00pm

PACKAGES

id	Address	Truck	Deadline	Notes	Time Delivered
1	195 W Oakland Ave	1	10:30 AM	N/A	08:22:00
2	2530 S 500 E	3	17:00 PM	N/A	undelivered
3	233 Canyon Rd	2	17:00 PM	truck 2	08:54:20
4	380 W 2880 S	1	17:00 PM	N/A	08:25:40
5	410 S State St	2	17:00 PM	N/A	10:07:00
6	3060 Lester St	1	10:30 AM	depart 9:05 am	08:41:20
7	1330 2100 S	1	17:00 PM	N/A	08:12:40
8	300 State St	1	17:00 PM	N/A	09:10:40
9	410 S State St	3	17:00 PM	Wrong address listed	10:50:20
10	600 E 900 South	3	17:00 PM	N/A	undelivered
11	2600 Taylorsville Blvd	3	17:00 PM	N/A	undelivered
12	3575 W Valley Central Station bus Loop	3	17:00 PM	N/A	11:57:20
13	2010 W 500 S	1	10:30 AM	N/A	08:56:40
14	4300 S 1300 E	2	10:30 AM	together 15;19	08:26:00
15	4580 S 2300 E	2	09:00 AM	N/A	08:19:20
16	4580 S 2300 E	2	10:30 AM	together 13;19	08:19:20
17	3148 S 1100 W	3	17:00 PM	N/A	undelivered
18	1488 4800 S	2	17:00 PM	truck 2	09:31:20
19	177 W Price Ave	3	17:00 PM	N/A	11:52:40
20	3595 Main St	1	10:30 AM	together 13;15	08:31:00
21	3595 Main St	1	17:00 PM	N/A	08:31:00
22	6351 South 900 East	3	17:00 PM	N/A	11:34:00
23	5100 South 2700 West	3	17:00 PM	N/A	undelivered
24	5025 State St	3	17:00 PM	N/A	11:44:20
25	5383 South 900 East #104	2	10:30 AM	depart 9:05 am	08:08:00
26	5383 South 900 East #104	2	17:00 PM	N/A	08:08:00
27	1060 Dalton Ave S	1	17:00 PM	N/A	08:51:20
28	2835 Main St	3	17:00 PM	depart 9:05 am	undelivered
29	1330 2100 S	1	10:30 AM	N/A	08:12:40
30	300 State St	1	10:30 AM	N/A	09:10:40
31	3365 S 900 W	1	10:30 AM	N/A	08:36:20
32	3365 S 900 W	1	17:00 PM	depart 9:05 am	08:36:20
33	2530 S 500 E	3	17:00 PM	N/A	undelivered
34	4580 S 2300 E	2	10:30 AM	N/A	08:19:20
35	1060 Dalton Ave S	1	17:00 PM	N/A	08:51:20
36	2300 Parkway Blvd	2	17:00 PM	truck 2	09:44:40
37	410 S State St	2	10:30 AM	N/A	10:07:00
38	410 S State St	2	17:00 PM	truck 2	10:07:00
39	2010 W 500 S	1	17:00 PM	N/A	08:56:40
40	380 W 2880 S	1	10:30 AM	N/A	08:25:40

Delivery Chart of which truck each delivery was assigned

DELIVERIES

id	Address	Truck	packages	deadline	ETA
1	1060 Dalton Ave S	1	27,35	17:00:00	08:51:20
2	1330 2100 S	1	7,29	10:30:00	08:12:40
3	1488 4800 S	2	18	17:00:00	09:31:20
4	177 W Price Ave	3	19	17:00:00	11:52:40
5	195 W Oakland Ave	1	1	10:30:00	08:22:00
6	2010 W 500 S	1	13,39	10:30:00	08:56:40
7	2300 Parkway Blvd	2	36	17:00:00	09:44:40
8	233 Canyon Rd	2	3	17:00:00	08:54:20
9	2530 S 500 E	3	2,33	17:00:00	12:28:40
10	2600 Taylorsville Blvd	3	11	17:00:00	12:58:20
11	2835 Main St	3	28	17:00:00	12:32:20
12	300 State St	1	8,30	10:30:00	09:10:40
13	3060 Lester St	1	6	10:30:00	08:41:20
14	3148 S 1100 W	3	17	17:00:00	12:41:00
15	3365 S 900 W	1	31,32	10:30:00	08:36:20
16	3575 W Valley Central Station bus Loop	3	12	17:00:00	11:57:20
17	3595 Main St	1	20,21	10:30:00	08:31:00
18	380 W 2880 S	1	4,40	10:30:00	08:25:40
19	410 S State St	2	5,37,38	10:30:00	10:07:00
20	4300 S 1300 E	2	14	10:30:00	08:26:00
21	4580 S 2300 E	2	15,16,34	09:00:00	08:19:20
22	5025 State St	3	24	17:00:00	11:44:20
23	5100 South 2700 West	3	23	17:00:00	12:57:00
24	5383 South 900 East #104	2	25,26	10:30:00	08:08:00
25	600 E 900 South	3	10	17:00:00	12:18:00
26	6351 South 900 East	3	22	17:00:00	11:34:00
27	410 S State St	3	9	17:00:00	10:50:20

Route table listing the locations each specified truck will go through throughout the day.

Routes

```
Route assigned to truck 1
 |- 1330 2100 S
 |- 195 W Oakland Ave
 |- 380 W 2880 S
 |- 3595 Main St
 |- 3365 S 900 W
 |- 3060 Lester St
 |- 1060 Dalton Ave S
 |- 2010 W 500 S
 |- 300 State St
Route assigned to truck 2
 |- 5383 South 900 East #104
 |- 4580 S 2300 E
 |- 4300 S 1300 E
 |- 233 Canyon Rd
 |- 1488 4800 S
 |- 2300 Parkway Blvd
 |- 410 S State St
Route assigned to truck 3
 |- 410 S State St
 |- 6351 South 900 East
 |- 5025 State St
 |- 177 W Price Ave
 |- 3575 W Valley Central Station bus Loop
 |- 600 E 900 South
 |- 2530 S 500 E
 |- 2835 Main St
 |- 3148 S 1100 W
 |- 5100 South 2700 West
 |- 2600 Taylorsville Blvd
```

Truck table notifying the current location of the truck, packages on board and miles it will travel during the assigned route.

Trucks

id	Current Location	Deliveries	Packages	Miles
1	4001 South 700 East	9	16	21.2
2	4001 South 700 East	7	12	44.6
3	4001 South 700 East	11	12	44.9

Total Miles: 110.7