C950 Task-2 WGUPS Write-Up

(Task-2: The implementation phase of the WGUPS Routing Program).

(Zip your source code and upload it with this file)

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Date: 8/11/23

C950 Data Structures and Algorithms II

# Stated Problem

The problem is to find efficient routes and distribution plans for package deliveries within the Western Governor University Parcel Service (WGUPS), utilizing Python 3.11. The task involves handling 40 packages scheduled for delivery. The packages are grouped by delivery deadlines; packages that must be delivered by 9:00 AM, packages that must be delivered by 10:30 AM, and packages that must be delivered by EOD which we will define as 5:00 PM. Additional challenges to the problem is that there is a limit of three trucks, two available drivers for delivery, and capacity limits. This means no more than two trucks can be out for delivery at any given time and load balancing is required to ensure that trucks are not loaded with more than 16 packages. To make the problem even more complicated, we must also account for delays in package arrival, requirements like grouped packages for delivery, and error handling of packages with incorrect delivery addresses. To address these challenges a systematic approach is required.

# Abstract

To address the problem and these challenges, this paper presents a comprehensive solution that utilizes algorithms and data structures to optimize package deliveries. The solution encompasses truck prioritization, the implementation of the nearest neighbor and two-opt algorithms for route optimization, and the utilization of Dijkstra's shortest path algorithm for precise route calculations. By integrating these components, this aims to enhance the efficiency and accuracy of package deliveries for WGUPS.

# Introduction

The Western Governor University Parcel Service (WGUPS) plays a pivotal role in facilitating timely package deliveries in a dynamic and demanding environment. With the objective of delivering 40 packages by the end of the day, WGUPS faces multiple challenges that necessitate a systematic approach to ensure successful and optimized deliveries. These challenges encompass the management of limited trucks and available drivers, compliance with diverse delivery deadlines, consideration of specific truck loading constraints, and the accommodation of special requirements such as grouped package deliveries and designated trucks for specific packages.

In response to these challenges, this paper presents a comprehensive solution approach designed to optimize package deliveries and maximize operational efficiency. The proposed approach is grounded in the utilization of algorithms and data structures, which collectively contribute to the optimization of package routes, adherence to deadlines, and efficient allocation of resources.

This paper is organized as follows: **Section 1** presents the classes and methods that we will utilize in managing packages, trucks, and delivery tracking. **Section 2** delves into the implementation details of each algorithm, emphasizing their role in optimizing package deliveries as well as the space-time complexity of the implementation. **Section 3** delves into the command line interface where we will simulate loading of packages, optimizing the routes, and the monitoring of packages during their delivery. **Section 4** delves into the evaluation of the strengths of our selected data structures and algorithms, alternative approaches , key findings of our approach, challenges faced, and possible areas of improvement, followed by a conclusion that summarizes the main contributions of the paper and underscores its significance for the field of logistics and route optimization.

By presenting a holistic solution approach, this paper aims to provide valuable insights and practical strategies that can be applied to real-world scenarios, enhancing the efficiency, accuracy, and effectiveness of package deliveries for organizations like WGUPS.

# Proposed Solution and Approach

Our approach consists of several steps aimed at optimizing package deliveries for the Western Governor University Parcel Service (WGUPS):

1. **Truck Prioritization:** The three available trucks will be prioritized based on package delivery deadlines. High priority(truck1) for packages with a delivery deadline of 9:00 AM, medium priority(truck2) with delivery deadline of 10:30 AM, and low priority(truck3) for packages with deliver deadline by EOD which will be defined as 5: 00 PM. This prioritization will for the foundation for efficient route planning and distribution.

2**. Nearest Neighbor Greedy Algorithm:** The core of our approach lies in the implementation of the self-adjusting heuristic Nearest Neighbor algorithm. The Nearest Neighbor algorithm is used to load packages onto each truck. It starts from the hub (starting point) and iteratively selects the nearest package or destination to visit next while keeping in mind individual package constraints. This process continues until all packages are assigned to the route.

The Nearest Neighbor algorithm is relatively simple and quick but may not always result in the most optimal route. In the context of the code, the Nearest Neighbor algorithm is used to load packages for each truck and create an initial route, which is then further optimized using Two-opt algorithm, and finally Dijkstra’s shortest path algorithm.

3. **Two-opt Greedy Algorithm:** The Two-opt algorithm is then applied to the initial routes created by the Nearest Neighbor algorithm. This algorithm attempts to improve the route by iteratively swapping pairs of edges to eliminate intersections and reduce the overall route distance. It helps refine the initial routes and make them more optimal.

After applying the Two-opt algorithm to the initial routes, Dijkstra's algorithm is used once again to calculate the shortest paths for the refined routes. This ensures that the routes remain optimized even further after the two-opt optimization.

4. **Dijkstra's Shortest Path Greedy Algorithm:** Dijkstra's algorithm is a graph traversal algorithm used to find the shortest paths from a source vertex (hub) to all other vertices (package delivery locations) in a weighted graph. In the code, Dijkstra's algorithm is used to calculate the shortest route from the hub to each package's delivery location, considering the distances between vertices (locations).

Dijkstra's algorithm ensures that the calculated routes are truly optimized in terms of minimizing the distance traveled. This algorithm provides a more accurate measure of the shortest routes compared to the initial routes generated by the nearest neighbor algorithm and two-opt algorithm. The final total distance calculated.

# Major Code Blocks

Implementation of data structures and created methods to manage packages, trucks, and the logic of loading and transportation. Our data is stored in two csv files. First, ‘WGUPS Package File Formatted.csv’ contains all the 40 packages required for delivery with their respective details such as package ID, delivery address, delivery deadline, and special notes. Second, ‘WGUPS\_Distances.csv’ contains distance information between various locations. Each row represents a specific location, and the columns provide distance values between that location and other locations.

## HashMap Class

The Hash Map Class is responsible for managing all 40 packages as key-value pairs. Where HashMapEntry Class defines a package object with its details to be loaded into HashMap. Using the package ID associated with each package as the key and the package object as the value for our key-value pairs.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Line Number | Summary | Method | Space Complexity | Time Complexity |
| 61 | Initialize an empty hash map | \_init\_\_ | O(N) | O(N) |
| 68 | Compute the hash bucket for a given key | get\_hash | O(1) | O(1) |
| 73 | Insert a new key-value pair into hash map | insert\_package | O(N) | O(N) |
| 98 | Retrieve value using a given key | get\_value\_from\_key | O(1) | O(N) |
| 110 | Retrieve key using given address | get\_address\_from\_key | O(1) | O(N) |
| 120 | Retrieve address using given key | get\_key\_from\_address | O(1) | O(N) |
| 127 | Retrieve the entire hash map | get\_hashmap | O(1) | O(1) |
| 130 | Retrieve packages in the hash map | get\_packages | O(1) | O(1) |
| 134 | Print details of all packages | print\_all\_packages | O(1) | O(N) |
| 150 | Update value for a given key | update\_value | O(1) | O(N) |
| 164 | Delete key-value pair using given key | delete\_key\_value | O(1) | O(N) |
| 181 | Load CSV data into the hash map | load\_hash\_map | O(N) | O(N) |
| 222 | Print details of all packages for testing | get\_hash\_map\_all | O(1) | O(N) |
| 228 | Check if all packages exist in the hash map | check\_all\_packages | O(1) | O(N) |
| Total |  |  | O(N) | O(N) |

## HashMapEntry Class

The HashMapEntry Class defines a package object with its details. To be loaded into HashMap Object

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Line Number | Summary | Method | Space Complexity | Time Complexity |
| 6 | Initialize package object with details | \_\_init\_\_ | O(1) | O(1) |
| 55 | String representation of package details | \_\_repr\_\_ | O(1) | O(1) |
| Total |  |  | O(1) | O(1) |

## Graph Class

The Graph Class represents a graph with vertices and edges.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Line Number | Summary | Method | Space Complexity | Time Complexity |
| 8 | Initialize graph with vertices and edges | \_\_init\_\_ | O(N) | O(1) |
| 16 | Add new vertex to graph | add\_vertex | O(1) | O(1) |
| 19 | Get all vertices from graph | get\_all\_vertices | O(N) | ON) |
| 24 | Add an edge between two vertices | add\_edge | O(1) | O(1) |
| 62 | Associate packages with graph vertices | insert\_packages\_vertex\_associate | O(N^2) | O(N^2) |
| 86 | Get vertex distances from CSV data | get\_csv\_vertex\_distances | O(N) | O(N) |
| 99 | Load graph with vertices and edges | load\_graph | O(N) | O(N^2) |
| 114 | Print edges and weights in the graph | print\_graph\_edge\_weights | O(1) | O(N^2) |
| 124 | Print edges and associated packages | print\_edges\_packages\_asc | O(1) | O(N) |
| 134 | Print vertices and their associated packages | print\_vertices\_packages\_asc | O(1) | O(N^2) |
| 154 | Print packages with specific deadline | print\_package\_deadline\_asc | O( N) | O(N^2) |
| Total |  |  | O(N^2) | O(N^2) |

## Trucks Class

The Trucks class will be where packages are to be loaded and simulation of delivery will take place

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Line Number | Summary | Method | Space Complexity | Time Complexity |
| 34 |  | \_\_init\_\_ | O(1) | O(1) |
| 46 |  | insert\_truck\_id | O(1) | O(1) |
| 60 |  | insert\_packages | O(1) | O(1) |
| 74 |  | get\_packages | O(1) | O(1) |
| 85 |  | remove\_packages | O(1) | O(1) |
| 98 |  | insert\_distances\_pred\_vertex | O(1) | O(1) |
| 112 |  | get\_distances | O(1) | O(1) |
| 123 |  | print\_packages | O(1) | O(N) |
| 131 |  | print\_route | O(1) | O(1) |
| 146 |  | get\_package\_count | O(1) | O(1) |
| 157 |  | set\_edge\_weights | O(1) | O(N) |
| 185 |  | load\_trucks | O(N) | O(N) |
| 251 |  | find\_shortest\_route\_to\_deliver | O(N) | O(N^2) |
| 296 |  | deliver\_packages | O(N) | O(N^2) |
| 371 |  | deliver\_truck3\_packages | O(1) | O(N^2) |
| Total |  |  | O(N) | O(N^2) |

## TimeTracker Class

The TimeTracker Class handles time-related aspects of truck deliveries.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Line Number | Summary | Method | Space Complexity | Time Complexity |
| 7 | Initialize TimeTracker object with package and truck delivery information | \_\_init\_\_ | O(1) | O(1) |
| 19 | Convert delivery deadline to time | convert\_deadline\_time | O(1) | O(1) |
| 27 | Format time to 24-hour format | format\_time | O(1) | O(1) |
| 36 | Get fixed truck speed | get\_truck\_speed | O(1) | O(1) |
| 39 | Initialize truck data | insert\_current\_truck | O(1) | O(1) |
| 51 | Get all trucks | get\_all\_trucks | O(N) | O(N)) |
| 57 | Remove truck’s data | remove\_current\_truck | O(1) | O(1) |
| 62 | Get status of all packages | get\_all\_package\_status | O(1) | O(1) |
| 66 | Lookup package and it’s status from package ID | lookup\_package\_status | O(1) | O(N) |
|  | Update packages status | update\_package\_status | O(1) | O(1) |
|  | Print status of all packages | print\_all\_package\_status | O(1) | O(N) |
|  | Initialize multiple package statuses | initialize\_multiple\_package\_status | O(1) | O(N) |
|  | Update time to start delivery of truck | update\_time\_to\_start\_delivery | O(1) | O(N) |
|  | Increment time of truck when delivering packages | increment\_current\_truck\_time | O(1) | O(1) |
|  | Get current time of truck | get\_current\_truck\_time | O(1) | O(1) |
|  | Update miles traveled of truck when delivering packages | update\_miles\_traveled | O(1) | O(1) |
|  | Print miles traveled of truck | print\_miles\_traveled | O(1) | O(1) |
|  | Calculate travel time | calculate\_travel\_time\_minutes | O(1) | O(1) |
|  | Update truck time when delivering packages | update\_current\_truck\_time | O(1) | O(1) |
|  | Insert time of delivery with package | insert\_current\_truck\_time\_to\_package | O(1) | O(1) |
|  | Check if trucks are ready for delivery | is\_ready\_to\_deliver | O(1) | O(N) |
|  | Check if truck’s delivery is complete | is\_delivery\_completed | O(1) | O(1) |
|  | Update package status | updated\_delivered\_delivery | O(1) | O(N) |
|  | Print packages with ‘DELIVERED’ status | print\_delivered\_status | O(N) | O(N) |
|  | Show packages within certain time ranges | filter\_packages\_by\_time\_range | O(N) | O(N) |
| Total |  |  | O(N) | O(N) |

B. Look-Up Function:

Trucks extends TimeTracker class to keep track of packages during their delivery. During delivery, ability to retrieve specific package from ID and the associated package data components and delivery status and time delivered based on the current time.

A screen shot of a computer program

Description automatically generated

C1. Identification Information

main.py screenshot goes here showing Student ID

C2. Process and Flow Comments

Some code blocks screenshots go here showing comments.

D. Interface

Interface screenshot goes here

D1. First Status Check

Screen shot goes here

D2. Second Status Check

Screenshot goes here

D3. Third Status Check

Screenshot goes here

E. Screenshot of Code Execution

Screenshot goes here

## Load\_Packages Functions

The Load\_Packages Functions consist of various helper functions for loading packages onto trucks in our approach. Methods with stars denote methods that are not utilized for our current implementation and were part of approach to manually load packages onto trucks.

(For the table below: k is number of special notes in the package constraints)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Line Number | Summary | Method | Space Complexity | Time Complexity |
| 7 | Get packages to load | get\_all\_packages\_to\_load | O(n) | O(n) |
| 28 | Check if packages can be loaded for current truck by constraints delivery deadline, special notes | can\_load\_packages | O(1) | O(1) |
| 69 | Check if package has any constraints; special notes | package\_has\_constraints | O(1) | O(k) |
| 89 | Randomize order of packages list | randomize\_packages | O(1) | O(n log n) (Shuffle) |
| 104 | Sort packages by distance from current vertex in graph | sort\_packages\_by\_distance | O(1) | O(n log n) |
| 121 | Load packages onto trucks based on constraints in less algorithmic approach | \*load\_packages\* | O(1) | O(n^2) |
| 210 | Get left over packages remaining by tracking packages already loaded | get\_left\_over\_packages | O(n) | O(n) |
| 237 | Load left over packages onto trucks | load\_left\_over\_packages | O(1) | O(n) |
| 299 | Return list of packages that meet low priority truck constraints | \*get\_package\_deadline\_constraints\_low\_asc | O(n) | O(n) |
| 332 | Returns list of packages that meet medium priority truck constraints | \*get\_package\_deadline\_constraints\_med\_asc | O(n) | O(n) |
| 365 | Return list of packages that meet high priority truck constraints | \*get\_package\_deadline\_constraints\_high\_asc | O(n) | O(n) |

# Algorithms

## Core Algorithm Analysis

The core algorithm focuses on efficiently loading packages onto trucks by utilizing a self-adjusting heuristic algorithm. The algorithm ensures that each truck follows a systematic approach to select and load packages. This overview highlights the algorithm's key steps, space complexity, and time complexity. This process continues until truck package count reaches 14 or all available packages are loaded, ensuring the truck travels to the nearest package at each step and return to hub.

**Space Complexity:**

The space complexity of the given nearest neighbor algorithm is O(n^2), where n represents the number of packages loaded onto the trucks. The primary contributors to the space complexity are the graph representation (which depends on the number of locations) and the lists storing package information (which depend on the number of packages).

**Time Complexity:**

The time complexity of this algorithm is O(n), where n is the number of packages on the truck. This is because package loading loop, that iterates until the truck’s package count reaches 14 or all available packages have been loaded onto the truck.

**Best- and Worst-Case Time Complexity:**

**Best Case:** The best-case time complexity of the nearest neighbor algorithm is O(n), where n is the number of packages on the truck. This occurs when the packages are already optimally ordered in a way that minimizes the distance traveled. For each package, the algorithm calculates the distance to all remaining packages and immediately finds the nearest one without needing to iterate through all the other packages. As a result, the algorithm completes in a linear time.

**Worst Case:** The worst-case time complexity occurs when the algorithm needs to consider all available packages multiple times and perform additional constraint checks leading to O(n^2). Here are the key factors contributing to the worst-case time complexity:

**Package Loading Loop**: In the worst case, the loop that loads packages onto the trucks needs to iterate through all available packages multiple times until each truck is fully loaded. This results in O(n) iterations, where n is the total number of packages.

**Constraint Checks**: For each available package, there are constraint checks to determine if it can be loaded onto the current truck. In the worst case, these checks could involve iterating through all packages again, leading to an additional O(n) factor.

## Core Algorithm Implementation

The core methodology details the implementation steps and processes involved in the truck package loading procedure. It covers initialization, package separation, nearest-neighbor loading, and completion and return steps.

1. Initialization:
2. Set the starting vertex of the truck's route to the hub vertex ('4001 South 700 East').
3. Get the list of remaining packages to load onto the truck using the graph and tracked package IDs.
4. Initialize the truck's route list with the hub vertex.

for each truck in trucks:

current\_vertex = '4001 South 700 East'

remaining\_packages = get\_all\_packages\_to\_load(graph, track\_package\_id)

truck.route = [current\_vertex]

1. Package Separation, iterate through the remaining packages:
2. Check if each package can be loaded onto the current truck:
   1. If it meets the current truck's constraints, add it to the constrained packages list.
   2. Otherwise, add it to the unconstrained packages list.

constrained\_packages = []

unconstrained\_packages = []

for each package in remaining\_packages:

if can\_load\_package(truck, package):

constrained\_packages.append(package)

else:

unconstrained\_packages.append(package)

1. Handling Unconstrained Packages:
   1. Remove unconstrained packages with constraints for the current truck from the unconstrained packages list.

unconstrained\_packages = filter out unconstrained packages with constraints

1. Nearest-Neighbor Loading:
2. Combine the constrained and unconstrained packages to form the list of all packages for the current truck.

all\_packages = constrained\_packages + unconstrained\_packages

1. While the truck's package count is less than 14 and there are still packages to load:
   1. Find the nearest package to the current vertex by calculating distances to all packages.
   2. If a suitable nearest package is found:
      1. Update the current vertex to the address of the loaded package.
      2. Insert the package onto the truck.
      3. Add the package's ID to the set of tracked package IDs.
      4. Remove the package from the list of all packages.
   3. If no suitable package is found, print a message indicating that no package was found.

while truck.get\_package\_count() < 14 and len(all\_packages) > 0:

min\_distance = infinity

nearest\_package = None

for each package in all\_packages:

dest\_vertex = package.address

distance = graph.edge\_weight[current\_vertex][dest\_vertex]

if distance < min\_distance:

min\_distance = distance

nearest\_package = package

if nearest\_package is not None:

current\_vertex = nearest\_package.address

truck.insert\_packages(nearest\_package)

track\_package\_id.add(nearest\_package.package\_id)

all\_packages.remove(nearest\_package)

else:

print "No suitable package found for truck", truck.truck\_id

1. Completion and Return:
2. Add the hub vertex to the truck's route to complete the route loop.
3. Print the truck's route.

truck.route.append('4001 South 700 East')

print "Truck", truck.truck\_id, "- Route:", truck.route

## Two-opt Algorithm Analysis

## Two-opt Algorithm Implementation

## REWORK-Dijkstra's Shortest Path Algorithm Analysis

The greedy algorithm is executed by doing the following:

1. For each truck, find the final optimized routes for minimum distances traveled.

2. Utilize a min-heap as a priority queue to prioritize processing vertices with the shortest known distance. This queue is continually updated to ensure efficient shortest path determination during execution.

3. Iterate over neighbors of a vertex and calculate the distance. If the calculated distance is smaller than the current known distance, update the minimum distance.

4. The algorithm returns minimum distances for all addresses associated with each truck package.

**Space Complexity:**

**Priority Queue:** Our implementation a priority queue (min-heap) to manage vertices by their distances. The space complexity the priority queue is O(n), where n is the number of vertices.

**Best- and Worst-Case Time Complexity:**

**Priority Queue (Min-Heap) Operations:** The core operation in Dijkstra's algorithm involves extracting the minimum element from a priority queue (min-heap) and updating its neighbors. The number of times this operation is performed depends on the number of vertices and edges in the graph.

**Best Case**: O ((V + E) \* log V), where V is the number of vertices and E is the number of edges. In the best case, the priority queue operations may be more efficient due to the specific distribution of edge weights and vertex connections.

**Worst Case**: O ((V + E) \* log V), where V is the number of vertices and E is the number of edges. In the worst case, all vertices and edges need to be processed.

**Updating Neighbors:** In each iteration, the algorithm updates the distances of neighboring vertices. This operation involves checking the distances and possibly updating them.

**Best Case**: O(V), where V is the number of vertices. In the best case, only a few neighbors need to be updated.

**Worst Case**: O(V), where V is the number of vertices. In the worst case, all neighbors need to be updated.

Considering these factors, the overall time complexity of Dijkstra's algorithm in this context is O ((V + E) \* log V). As of now there are only 40 packages.

## Dijkstra's Algorithm Implementation

1. Takes two parameters graph object (associated packages with address acting as vertices and edge weights acting as distance to each address) and src the current location (by default always at hub), and route (the route the truck takes after using nearest-neighbor and two-opt algorithm)

2. Initializes 'distances' dictionary of all vertices in the graph to infinity that is in the route, except for the src, which is set to 0.

3. A min-heap represented as a list of tuples (distances, vertex), is created to prioritize processing of vertices with the shortest known distance first. Initially, the src and distance of 0 are added to the min-heap.

4. Enters while loop that continues until the min-heap is empty. In each iteration, the vertex with the smallest distance is popped from the min-heap. If the vertex has already been visited and its current distance is greater than the distance stored in 'distances' dictionary, then the iteration is skipped.

5. Popped vertex is marked as visited and its neighbors are iterated over. For each neighbor, the function calculates the distance from the source vertex to the neighbor by adding the weight of the edge connecting them to the current distance. If this calculated distance is smaller than the current known distance to the neighbor, the `distances` dictionary is updated with the new, smaller distance.

6. Finally, the updated distance and neighbor vertex are pushed into the min-heap, ensuring that the neighbor vertex will be processed later with its updated distance.

7. Once loop is finished, function 'distance' dictionary will contain the shortest distances for packages to be returned

# User Interface and Status Check

## User Interface

D. Interface

Provide an intuitive interface for the user to view the delivery status (including the delivery time)

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.)

Interface screenshot goes here.

Here in the first screenshot for example, they are asking for anytime requested by the user.

between 8:35am and 9:25am.

## Status Check

D1. First Status Check

1. Provide screenshots to show the status of all packages loaded onto each truck at a time

between 8:35 a.m. and 9:25 a.m.

Screen shot goes here

D2. Second Status Check

2. Provide screenshots to show the status of all packages loaded onto each truck at a time

between 9:35 a.m. and 10:25 a.m.

Screenshot goes here

D3. Third Status Check

3. Provide screenshots to show the status of all packages loaded onto each truck at a time

between 12:03 p.m. and 1:12 p.m.

Screenshot goes here

E. Screenshot of Code Execution

Provide screenshots showing successful completion of the code that includes the total mileage

traveled by all trucks.

Provide a screenshot or screenshots so that the evaluator can check that your code ran on your

machine successfully to completion. The screenshot(s) should include a view of the console

output, the project files, etc.

# Data Structure and Algorithm Evaluation

## Data Structures Evaluation

### Graph

H. Verification of Data Structure

Text goes here

H1. Other Data Structures

Text goes here

H1a. Data Structure Differences

Text goes here

### HashMap

H. Verification of Data Structure

Text goes here

H1. Other Data Structures

Text goes here

H1a. Data Structure Differences

Text goes here

## Algorithms Evaluation

F1. Strengths of the Chosen Algorithm

Text goes here

F2. Verification of Algorithm

Text goes here

## Alternative Algorithm Approaches

F3. Other Possible Algorithms

Text goes here

F3a. Algorithm Differences

Text goes here

G. Different Approach

Text goes here

## Results and Discussion

Summarize the key findings of your approach's implementation.

Analyze the efficiency and accuracy of the solution in optimizing package deliveries.

Discuss any challenges faced during implementation and possible areas for improvement.

# Conclusion

Summarize the main points of your paper, including the problem, solution approach, and results.

Highlight the significance of your solution for WGUPS and similar delivery optimization challenges.

# References

List of all sources cited in the paper, following a specific citation style (e.g., APA, MLA)

I. Sources

Text goes here

An example:

Lysecky, R., & Vahid, F. (2018, June). *C950: Data Structures and Algorithms II*. zyBooks.

Retrieved March 22, 2021, from <https://learn.zybooks.com/zybook/WGUC950AY20182019/>

# Appendices

Include any supplementary materials, such as full code listings, screenshots, or additional details that support your paper.

J. Professional Communication