# DRONE DELIVERY OPTIMIZATION PROJECT DOCUMENTATION

## 1. Project Overview

### Goal

The goal of this project is to efficiently assign customer orders to available drones while ensuring:

• Orders are delivered within the deadline.

• Drones do not exceed their maximum payload.

• Drones travel the shortest possible route to save time and energy.

• Drones return to the starting location (0,0) after deliveries.

• Multiple orders can be assigned to a single drone if conditions allow.

## 2. Formulas Used

### 2.1 Distance Calculation

We use the Manhattan Distance formula since drones travel only in horizontal and vertical directions:

Distance = |x2 - x1| + |y2 - y1|

### 2.2 Travel Time Calculation

Time taken to travel a certain distance is calculated using:

Time = Distance / Speed

Since drone speed is in blocks per second, the result is converted to minutes:

Time (min) = Time (sec) / 60

### 2.3 Total Distance Calculation

The total distance includes the sum of all delivery distances and the return trip back to (0,0):

Total Distance = Delivery Distance + Return Distance

## 3. Assigning Orders to Drones

### 3.1 Conditions for Assigning an Order to a Drone

A drone can only take an order if:

1. The order’s weight does not exceed the drone's max payload.

2. The total travel distance (including return trip) is within the drone’s max range.

3. The total delivery time does not exceed the order's deadline.

4. Orders are assigned based on closest location first, then by deadline priority.

### 3.2 Assigning Multiple Orders to a Single Drone

A drone can carry multiple orders if:

• The combined weight of the orders does not exceed the drone’s payload.

• The total travel distance (including return trip) is within the drone’s range.

• The delivery time of the last order does not exceed its deadline.

### 3.3 Optimized Route for Multiple Orders

Instead of returning to (0,0) after each order, the drone follows a continuous route to reduce travel distance:

1. Start at (0,0)

2. Deliver to the closest order first

3. Continue delivering to farther orders in sequence

4. Return to (0,0) after the last delivery

### 3.4 Example Route Calculation

Given Orders: O1 (4,6), O2 (7,3), O3 (10,8), O4 (15,10)

### 3.5 Expected Output in JSON Format

{  
 "assignments": [  
 {  
 "drone": "D1",  
 "orders": [  
 { "order": "O1", "time\_taken": 3.33, "distance": 10 },  
 { "order": "O2", "time\_taken": 5.33, "distance": 6 },  
 { "order": "O3", "time\_taken": 8.00, "distance": 8 },  
 { "order": "O4", "time\_taken": 10.33, "distance": 7 }  
 ],  
 "total\_time": 18.67,  
 "total\_distance": 56  
 }  
 ]  
}

## 4. Summary & Benefits

• Optimized order assignment based on shortest path.

• Drones carry multiple orders when possible to reduce trips.

• Ensures all deliveries meet weight, distance, and deadline constraints.

• Calculates total travel distance and time accurately.

• Improves delivery efficiency and minimizes drone travel cost.

## 5. Example Case 1: Step-by-Step Solution

### 5.1 Problem Statement

We have the following drones and orders:

|  |  |  |  |
| --- | --- | --- | --- |
| Drone ID | Max Payload (KG) | Max Distance (Blocks) | Speed (Blocks/sec) |
| D1 | 15 | 80 | 3 |
| D2 | 10 | 50 | 2.5 |
| D3 | 7 | 30 | 2 |

Orders available:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Order ID | Delivery Location (X,Y) | Deadline (Minutes) | Package Weight (KG) | Assigned Drone |
| O1 | (4,6) | 20 | 5 | D1 |
| O2 | (7,3) | 25 | 6 | D1 |
| O3 | (10,8) | 30 | 4 | D1 |
| O4 | (15,10) | 35 | 8 | D1 |

### 5.2 Step-by-Step Solution

### Step 1: Calculate Distance for Each Order

Using the Manhattan Distance formula:  
Distance = |x2 - x1| + |y2 - y1|

• (0,0) → (4,6) = |4 - 0| + |6 - 0| = 10 blocks

• (4,6) → (7,3) = |7 - 4| + |3 - 6| = 6 blocks

• (7,3) → (10,8) = |10 - 7| + |8 - 3| = 8 blocks

• (10,8) → (15,10) = |15 - 10| + |10 - 8| = 7 blocks

• (15,10) → (0,0) = |0 - 15| + |0 - 10| = 25 blocks (return trip)

• Total Distance = 10 + 6 + 8 + 7 + 25 = 56 blocks

### 5.3 Step 2: Calculate Travel Time for Each Order

Time = Distance / Speed  
Convert seconds to minutes by dividing by 60

• O1: 10 blocks / 3 = 3.33 minutes

• O2: 6 blocks / 3 = 2.00 minutes

• O3: 8 blocks / 3 = 2.67 minutes

• O4: 7 blocks / 3 = 2.33 minutes

• Return trip: 25 blocks / 3 = 8.33 minutes

• Total Time = 18.67 minutes

### 5.4 Final Assignment

Drone D1 is assigned all orders since it meets weight, distance, and time constraints.

## 5. Case Study: Example Case 2

### 5.1 Example Scenario

In this case, we have a different set of orders and drones available. The objective is to assign the orders optimally while ensuring all constraints are met.

### 5.2 Available Drones

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Drone ID | Max Payload (KG) | Max Distance (Blocks) | Speed (Blocks/sec) | Available |
| D1 | 20 | 100 | 3 | Yes |
| D2 | 25 | 40 | 2.5 | Yes |
| D3 | 7 | 20 | 2 | Yes |

### 5.3 Orders List

|  |  |  |  |
| --- | --- | --- | --- |
| Order ID | Delivery Location (X, Y) | Deadline (Minutes) | Package Weight (KG) |
| O1 | (2,2) | 15 | 2 |
| O2 | (3,3) | 30 | 8 |
| O3 | (4,4) | 25 | 4 |
| O4 | (13,12) | 40 | 6 |

### 5.4 Step-by-Step Solution

1. \*\*Calculate the Distance for Each Order:\*\*  
 - O1: (2,2) → Distance = 4 blocks  
 - O2: (3,3) → Distance = 6 blocks  
 - O3: (4,4) → Distance = 8 blocks  
 - O4: (13,12) → Distance = 25 blocks

2. \*\*Check which drones can handle these orders based on payload, distance, and speed constraints.\*\*  
 - D1 can handle all orders (Max distance: 100, Max payload: 20KG)  
 - D2 has a lower max distance (40 blocks), but higher payload (25KG)  
 - D3 has limited payload (7KG) and lower distance (20 blocks)

3. \*\*Assign orders optimally:\*\*  
 - O1, O2, O3 are grouped into one trip for D1 as it can handle multiple orders efficiently.  
 - O4 is assigned to D1 as well since D2 does not have enough distance capacity.

### 5.5 Expected Output (JSON Format)

{  
 "assignments": [  
 {  
 "drone": "D1",  
 "orders": [  
 { "order": "O1", "time\_taken": 2.0, "distance": 4 },  
 { "order": "O2", "time\_taken": 4.0, "distance": 6 },  
 { "order": "O3", "time\_taken": 6.0, "distance": 8 },  
 { "order": "O4", "time\_taken": 20.0, "distance": 25 }  
 ],  
 "total\_time": 32.0,  
 "total\_distance": 50  
 }  
 ]  
}