REVISED MODEL

Optimization Model for Grouping Orders

Objective Function

Goal:

Maximize the efficiency of order grouping to minimize delivery times and improve courier utilization while maintaining customer satisfaction.

Objective Function:

Maximize the number of grouped orders:

$$\text{Maximize } Z = \sum_{i \in O} \sum_{j \in O, j \neq i} x_{ij}$$

Where:

- O is the set of all orders.
- x_{ij} is a binary variable that is 1 if order i is grouped with order j, and 0 otherwise.

Constraints

1. Grouping Constraints:

- Symmetry Constraint for Grouping:
  $x_{ij} = x_{ji}, \forall i, j \in O$
  Ensures that if order i is grouped with order j, then order j is also grouped with order i.
- Orders Can Only Be Grouped if They Are Both Eligible:
  $x_{ij} \leq y_i \cdot y_j, \forall i, j \in O$
  Ensures orders can only be grouped if both orders are eligible for grouping. This directly ties to the objective function by restricting the values of x_{ij}.

2. Distance and Time Window Constraints:

- Distance Between Orders Must Be Within the Maximum Allowable Distance:
  $x_{ij} \cdot d_{ij} \leq \text{MaxDistance}, \forall i, j \in O$
  Ensures that only orders within a certain distance are grouped. By incorporating x_{ij}, we directly tie the constraint to the objective function.
- Time Window for Grouping Orders:
  $x_{ij} \cdot (t_j - t_i) \leq \tau, \forall i, j \in O$
  Ensures orders are only grouped if they fall within the specified time window. This constraint directly affects x_{ij}.

3. Customer Satisfaction Constraints:

- Ensure the Delay for Any Grouped Order Does Not Exceed the Maximum Allowable Delay:
  $x_{ij} \cdot \Delta T_i \leq \Delta T_{\max}, \forall i, j \in O$
  Maintains service quality by ensuring timely deliveries, directly tying the grouping variable x_{ij} to delivery constraints.

4. Each order must be dispatched either grouped or on its own:

$$\sum_{j \in O, j \neq i} x_{ij} + y_i = 1, \quad \forall i \in O$$

Assumptions of Our Model

Homogeneous Couriers: All couriers are assumed to have the same capabilities and constraints (e.g., speed, capacity).

Fixed Geographic Locations: Pickup and delivery locations are fixed and known in advance.

Constant Travel Times: Travel times between locations are assumed to be constant and not affected by traffic conditions or other dynamic factors.

Exact Preparation Times: Meal preparation times are accurately estimated and do not vary.

Binary Grouping Decisions: Each pair of orders can either be grouped or not, with no partial grouping allowed.

Symmetric Grouping: If order i is grouped with order j then order j is also grouped with order i.

Maximum Distance and Time Windows: There are predefined maximum distances and time windows within which orders can be grouped.

Customer Satisfaction: There is a maximum allowable delay that can be tolerated without significantly affecting customer satisfaction.

What Are We Evaluating?

Efficiency of Order Grouping: The primary objective is to maximize the efficiency of order grouping to minimize delivery times and improve courier utilization.

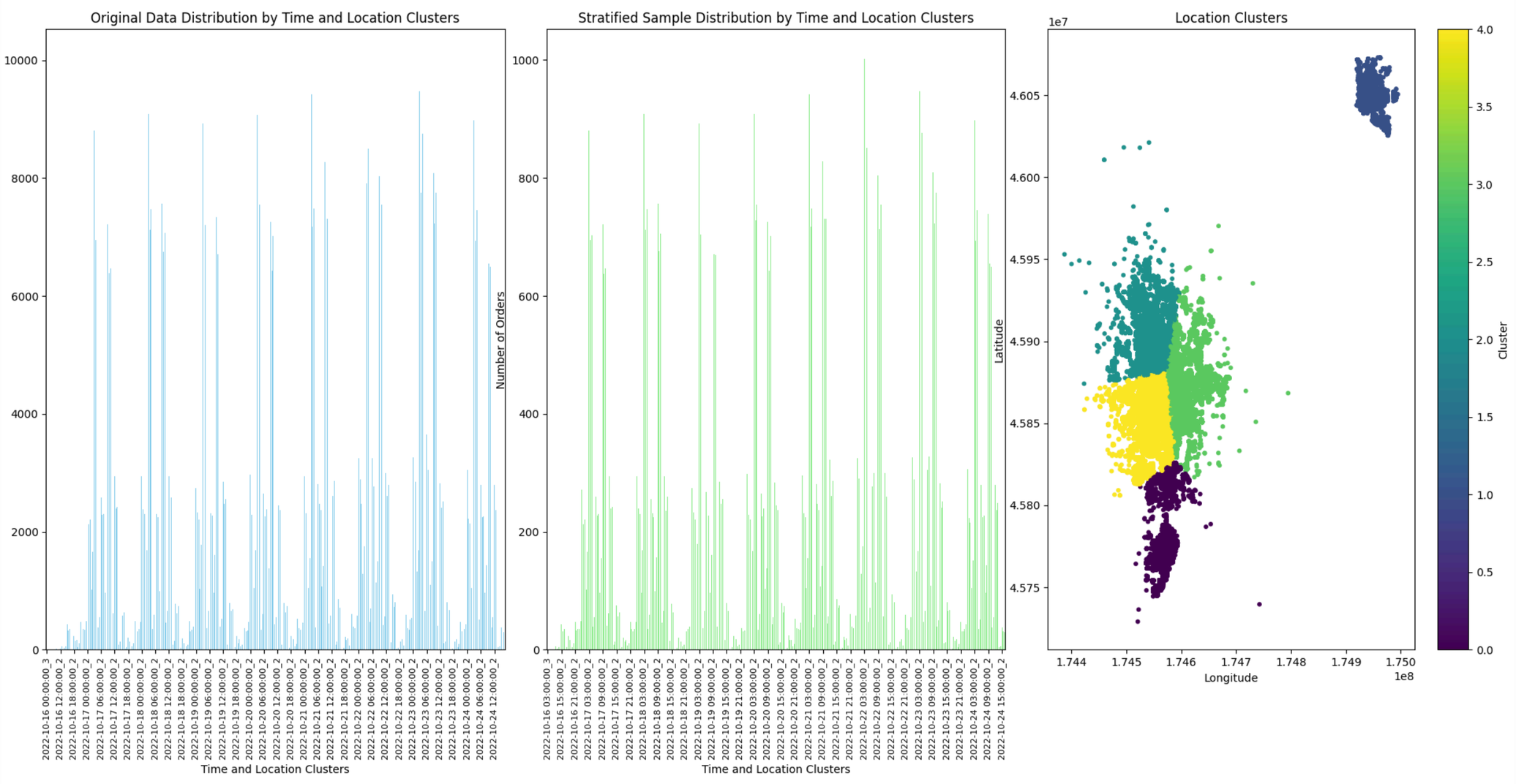
Delivery Times: How the grouping affects the average and total delivery times.

Courier Utilization: The number of orders delivered per courier per unit time.

Customer Satisfaction: Ensuring that delivery delays do not exceed the maximum allowable delay.

System Throughput: The overall throughput of the delivery system, i.e., the number of orders successfully delivered within the specified constraints.

Sampled Data



Sampling method

1. Stratification:
    - The dataset's order creation times are segmented into 3-hour intervals. This temporal stratification captures variations in order patterns throughout the day, ensuring that different times of day are well-represented in the sample.
2. Spatial Clustering:
    - K-Means clustering is applied to the geographical coordinates (latitude and longitude) of delivery locations to create location clusters. This spatial clustering ensures that the sample maintains the geographical diversity of the original dataset.
3. Combined Stratification:
    - A stratification column is created by combining the time intervals and location clusters. This ensures that both temporal and spatial aspects are considered in the sampling process.

4. Stratified Sampling:

   Using the combined stratification column, stratified sampling is performed to create a sample that is 10% of the original dataset. This approach ensures that the sample accurately represents the temporal and spatial distributions of the original data.

5. Visualization:

   To verify the representativeness of the sample, distributions of the original and sampled data are compared. Additionally, a scatter plot visualizes the location clusters to confirm the spatial stratification.