Delivery Zone Definition using K-Medoids and Integer Programming

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J.B. Hunt Final Mile Delivery Zones

J.B. Hunt is a transportation logistics company that offers a range of shipment and carrier solutions. Its Final Mile business unit defines delivery zones for its customers to reduce weekly mileage. Though it effectively reduces miles per stop by 26% on average, the manual process of creating zones is time-consuming and does not guarantee the best route mileage.

Optimizing Day to Zone Assignments

We use an integer program to assign delivery days to zones. The objective is to minimize the sum of the differences in volume between each pair of delivery days.

Sets
Set J of delivery days (input by user, could be 5 or 6)
Set C of clusters

Parameters
V_c = total volume for cluster c
D = user input for setting the minimum number of days per zone

Decision Variables
$x_{cj} = \begin{cases} 1 \text{ if cluster c is assigned to delivery day } j \\ 0 \text{ otherwise} \end{cases}$

S_j = total volume assigned to day j

$Z_{jj'}$ = absolute difference between S_j and $S_{j'}$

Objective
Minimize $\sum_{jj'} Z_{jj'}$

Constraints
Each cluster must be assigned to at least one delivery day

Predefined Zone (1) is assigned every delivery day

Invalid day constraints

Non-central zones must not be assigned all days
Percentage-based preset number of days

Binary constraints

Geographic Component of Algorithm

Our algorithm considers a factor for geographic location of zones to ensure mileage is reduced by enforcing additional constraints. We project a Cartesian coordinate plane onto the customer area and add constraints that zones lying in different quadrants are not assigned the same delivery days.
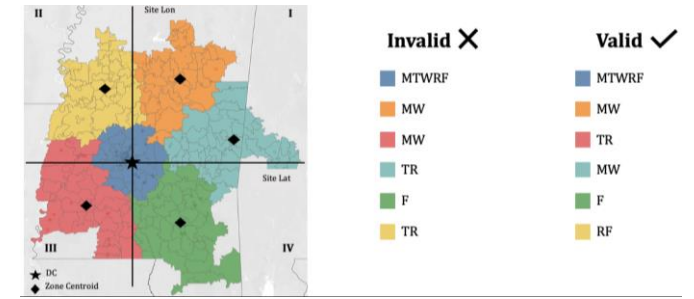

Assigning Zip Codes to Zones

We use the CH stopping rule to determine the how many zones to create and assign high-volume Zip Codes near the DC to a predefined zone. We set its size based on the volume distributed to the other zones, which are created by assigning the remaining Zip Codes using K-Medoids with volume-weighted centroid balancing.

Percent of Total Volume
28.9%
25.5%
12.9%
7.3%
12.1%
13.3%

★ DC
◆ Zone Centroid
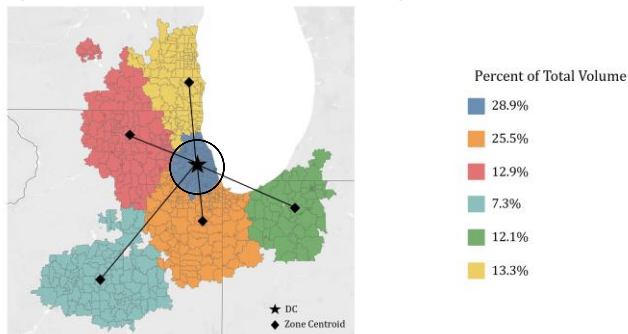
Optimization by Complete Enumeration

To solve this, we use complete enumeration to assign delivery days to zones such that daily volume is balanced throughout the week.
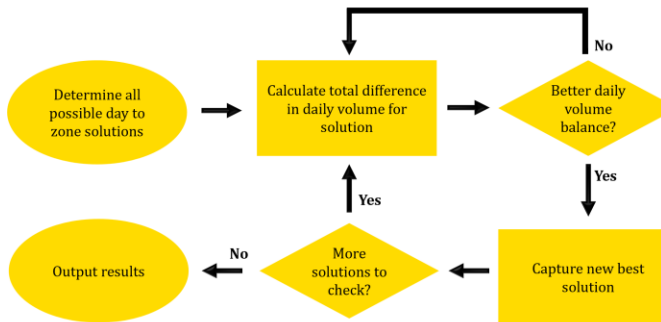
Impact and Results

Our results show a significant decrease in miles per stop compared to J.B. Hunt delivery zones, with an average reduction of 8%. Also, our tool reduces the time of creating zones from 10 hours to 4 minutes on average.