# Logistics - Transportation

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# Outline

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# Constraint Problem for Initial Feasible Routes

## Constants

$V$: number of vehicles

$C$: number of customers

$d(l)$: demand of each customer

$D$: capacity per vehicle

## Variables

$\forall c \in \{1, \ldots, C\}, \texttt{vehicleC}(c) \in \{1, ..., V\}$: vehicle paired to given customer

## Constraints

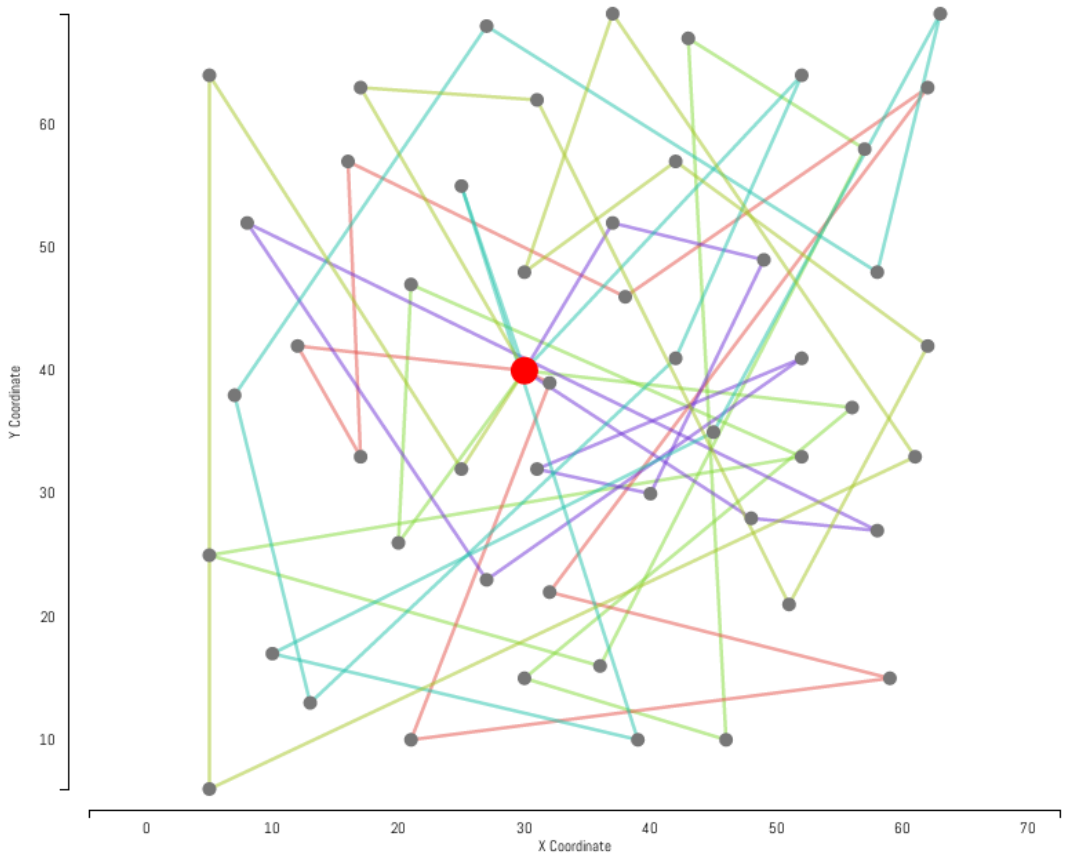
$$\forall v \in \{1, ..., V\} \quad \sum_{\texttt{vehicleC}(c)=v} d(c) \leq D$$

# Initial Feasible Solution Results

| Problem | |
|---|---|
| Customers | 51 |
| Vehicle Count | 5 |
| Vehicle Capacity | 160 |

| Your Solution | |
|---|---|
| Objective Value | 1610.3112 |
| Optimal? | 0 |
| Vehicles Used | 5 |

| Vehicle # | Used Capacity |
|---|---|
| Vehicle 1 | 159 |
| Vehicle 2 | 148 |
| Vehicle 3 | 152 |
| Vehicle 4 | 160 |
| Vehicle 5 | 158 |

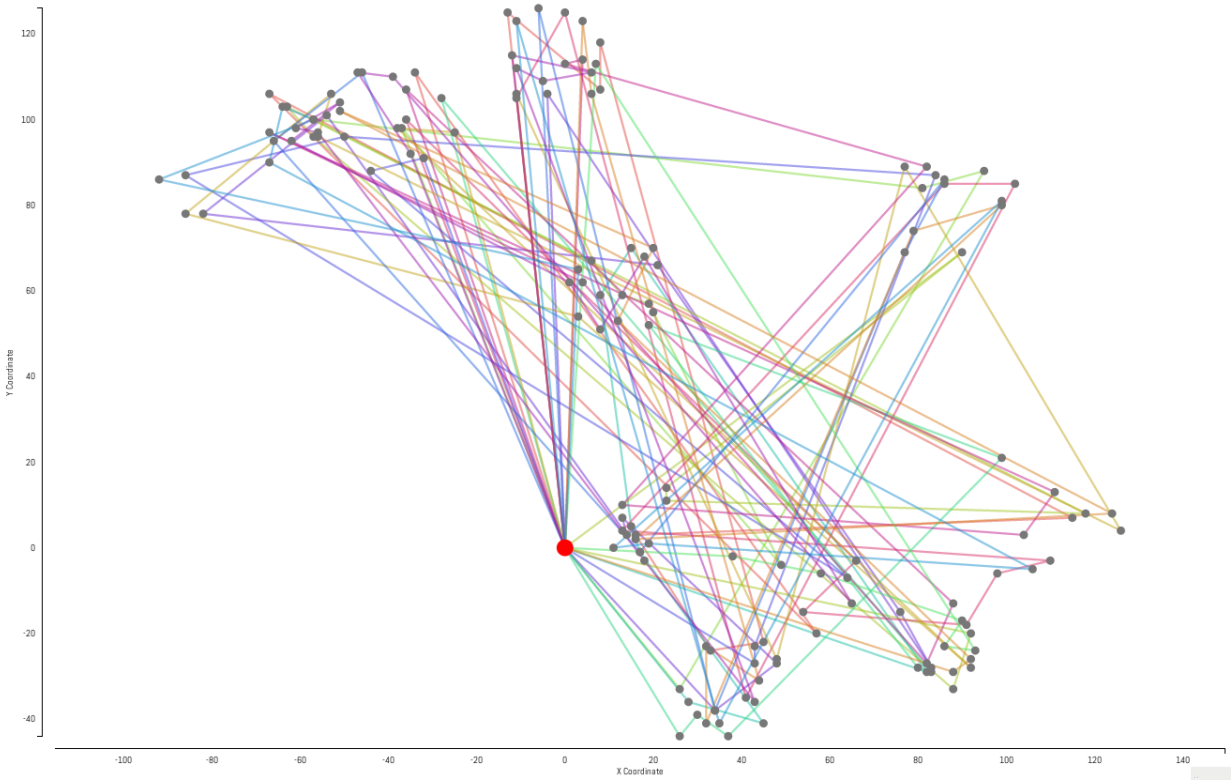


# Initial Feasible Solution Results

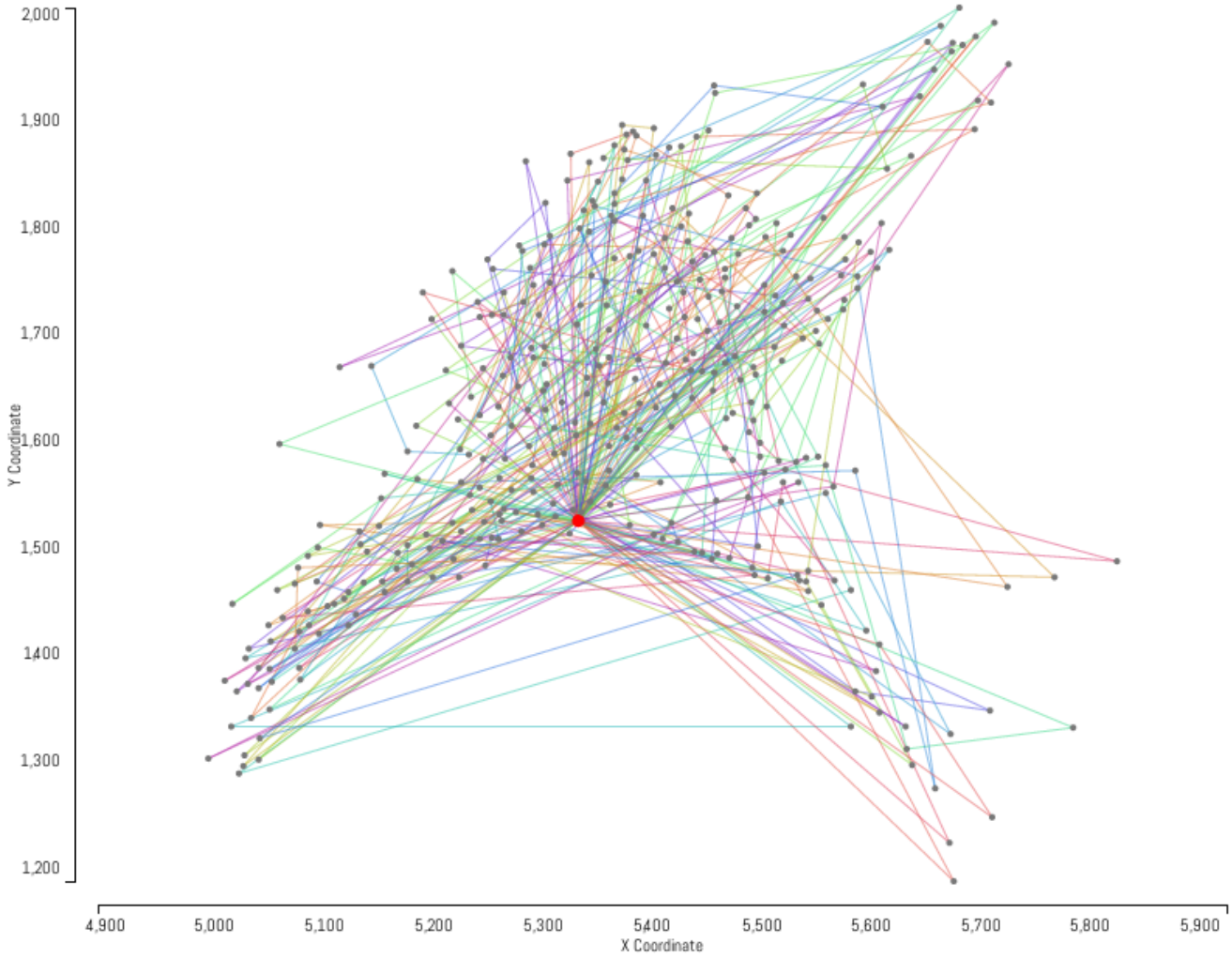
| Problem | |
|---|---|
| Customers | 151 |
| Vehicle Count | 15 |
| Vehicle Capacity | 1544 |

| Your Solution | |
|---|---|
| Objective Value | 12970.6731 |
| Optimal? | 0 |
| Vehicles Used | 15 |

| Vehicle # | Used Capacity |
|---|---|
| Vehicle 1 | 1541 |
| Vehicle 2 | 1388 |
| Vehicle 3 | 1421 |
| Vehicle 4 | 1534 |
| Vehicle 5 | 1534 |
| Vehicle 6 | 1282 |
| Vehicle 7 | 1521 |
| Vehicle 8 | 1422 |
| Vehicle 9 | 1531 |
| Vehicle 10 | 1538 |
| Vehicle 11 | 1360 |
| Vehicle 12 | 1401 |
| Vehicle 13 | 1534 |
| Vehicle 14 | 1501 |
| Vehicle 15 | 1323 |



# Initial Feasible Solution Results



# Outline

# Simulated Annealing

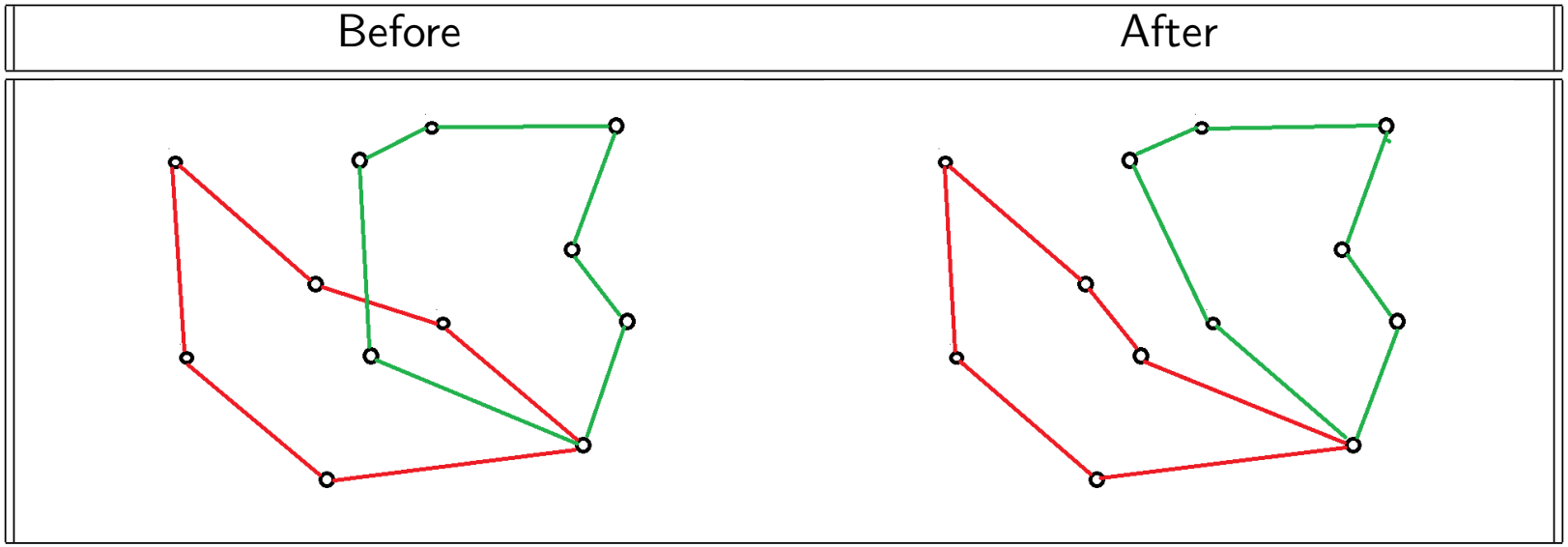
- Randomly generate configuration $s'$ from $s$. Probabilistically accept proposals with temperature parameter $T$:

$$\text{Prob(Accept proposal } s') = \begin{cases} 1 & d(s') < d(s) \\ \exp \frac{d(s)-d(s')}{T} & \text{Otherwise} \end{cases}$$

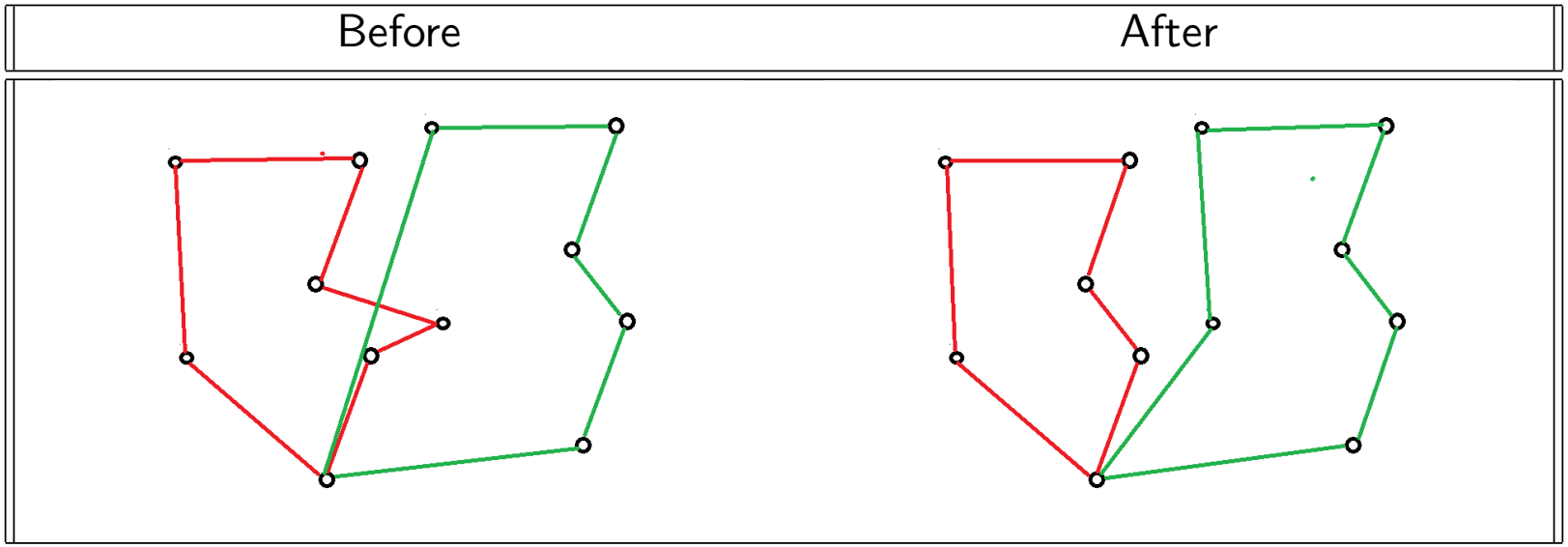
- Only accept if satisfies capacity constraints.
- Each proposal has 2 degrees of freedom, so use $O(n^2)$ proposals before reducing the temperature.
- Reduce temperature by 0.95. If at least 97% of proposals accepted, multiply by 0.5 instead.
- Terminate after 5 temperature reductions in a row with no significant distance changes.
- Repeat entire process (with new feasible solution).

# Outline

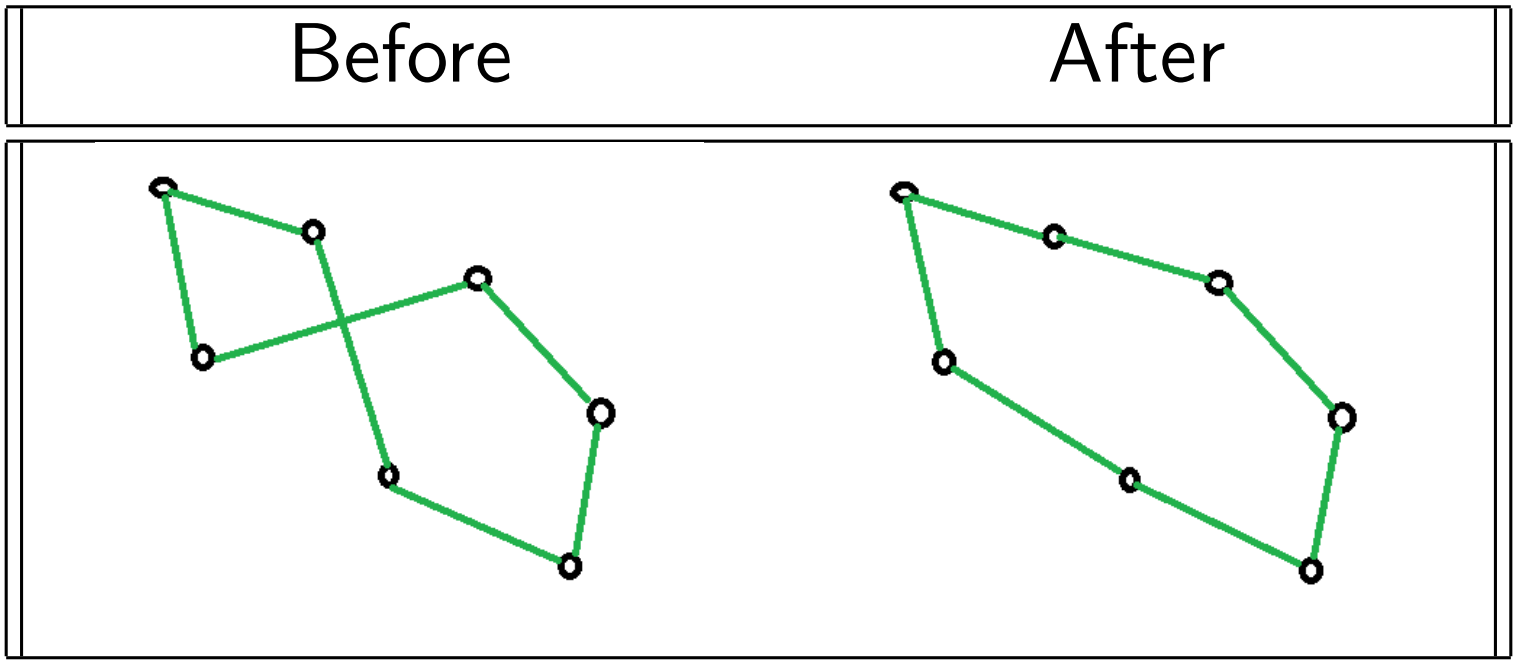
# Customer Swap Proposal



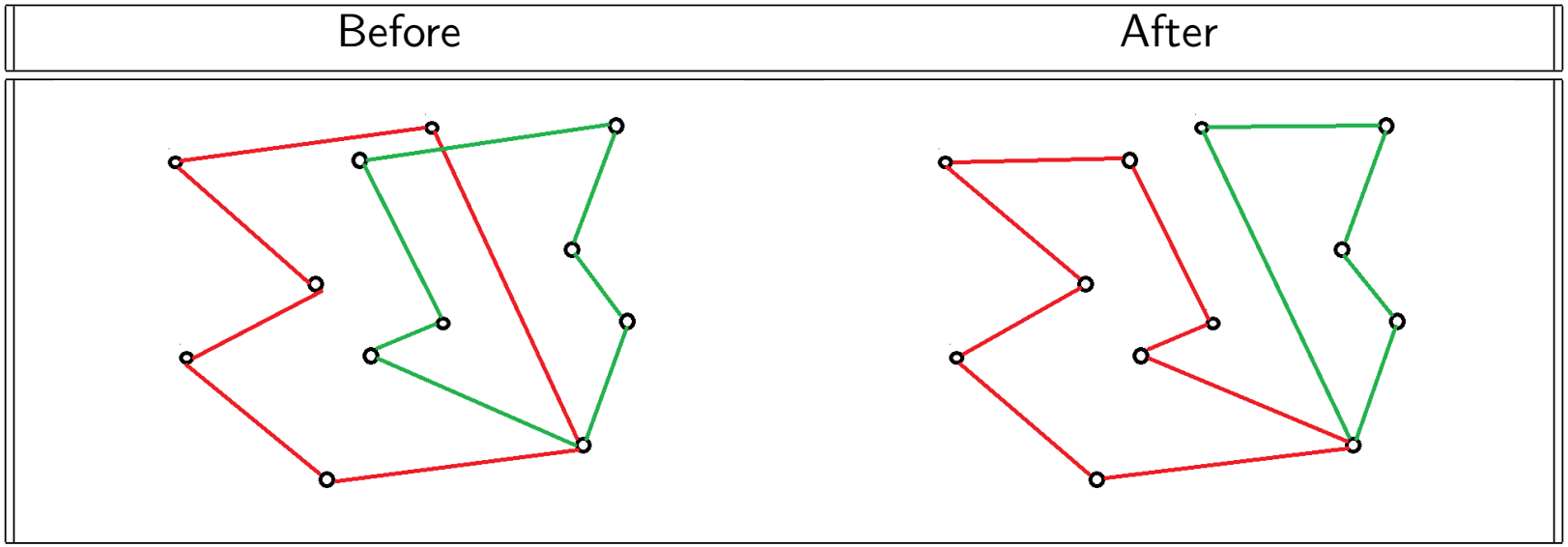
# Customer Move Proposal



# Route Reversal Proposal



# Route Splitting Swap Proposal



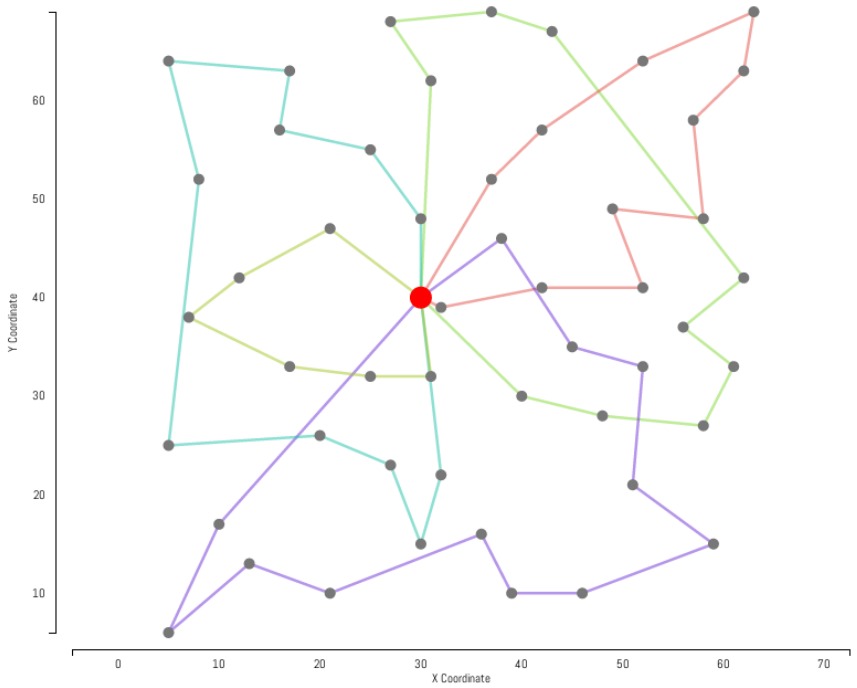
# Summary

| Instance | Customer Swap | Customer Move | Route Reversal | Route Splitting | Combined |
|---|---|---|---|---|---|
| 51 - 5 | $\downarrow 63\%$ | $\downarrow 63\%$ | $\downarrow 39\%$ | $\downarrow 56\%$ | $\downarrow 62\%$ |
| 151 - 15 | $\downarrow 73\%$ | $\downarrow 73\%$ | $\downarrow 44\%$ | $\downarrow 73\%$ | $\downarrow 73\%$ |
| 386 - 47 | $\downarrow 41\%$ | $\downarrow 34\%$ | $\downarrow 25\%$ | $\downarrow 58\%$ | $\downarrow 51\%$ |

# Summary

| Problem | |
|---|---|
| Customers | 51 |
| Vehicle Count | 5 |
| Vehicle Capacity | 160 |

| Your Solution | |
|---|---|
| Objective Value | 598.2189 |
| Optimal? | 0 |
| Vehicles Used | 5 |
| Vehicle # | Used Capacity |
| Vehicle 1 | 157 |
| Vehicle 2 | 157 |
| Vehicle 3 | 156 |
| Vehicle 4 | 148 |
| Vehicle 5 | 159 |

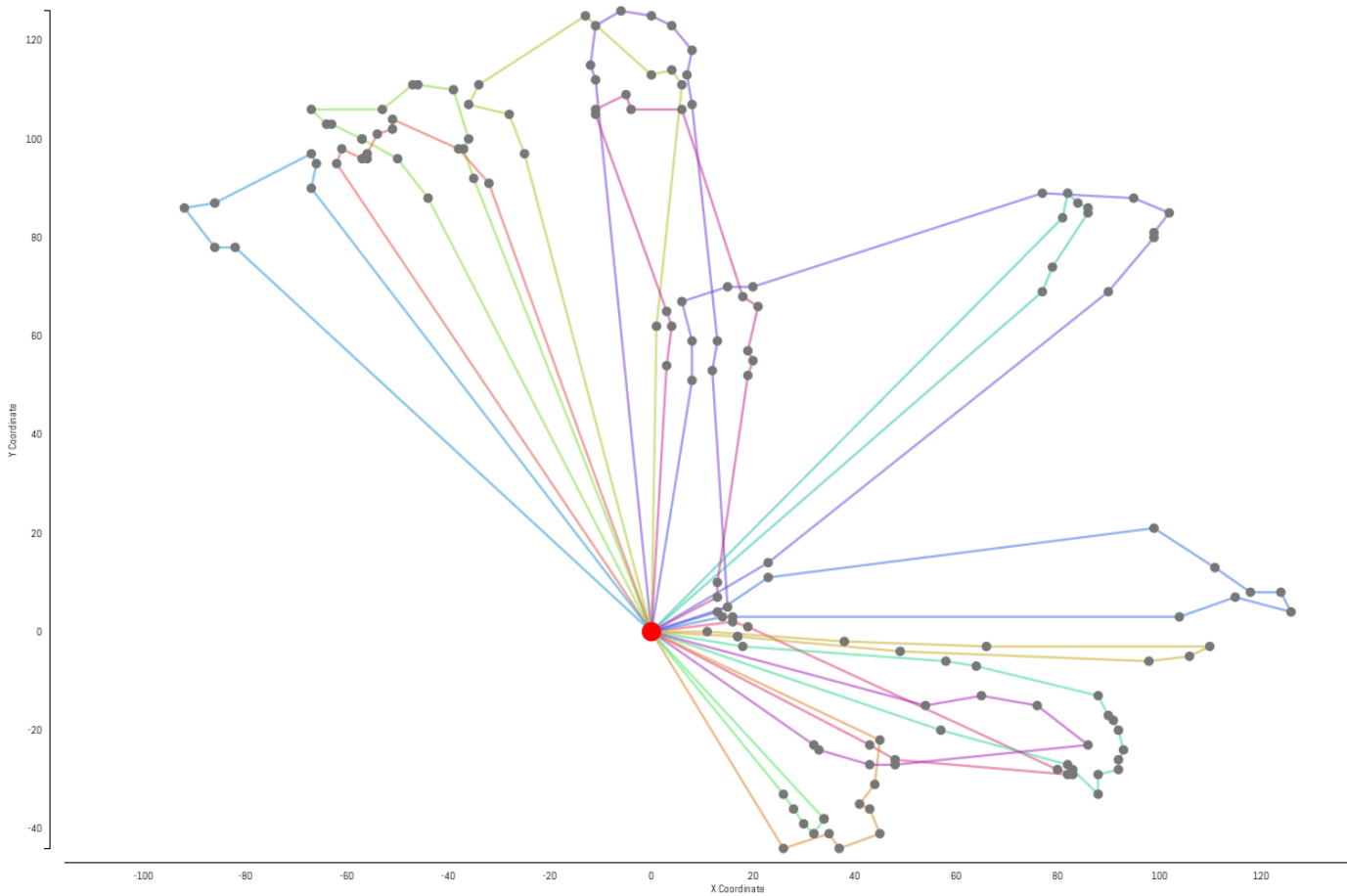


# Summary

| Problem | |
|---|---|
| Customers | 151 |
| Vehicle Count | 15 |
| Vehicle Capacity | 1544 |

| Your Solution | |
|---|---|
| Objective Value | 3469.8442 |
| Optimal? | 0 |
| Vehicles Used | 15 |

| Vehicle # | Used Capacity |
|---|---|
| Vehicle 1 | 1462 |
| Vehicle 2 | 1308 |
| Vehicle 3 | 1540 |
| Vehicle 4 | 1423 |
| Vehicle 5 | 1443 |
| Vehicle 6 | 1544 |
| Vehicle 7 | 1490 |
| Vehicle 8 | 1479 |
| Vehicle 9 | 1485 |
| Vehicle 10 | 1520 |
| Vehicle 11 | 1452 |
| Vehicle 12 | 1391 |
| Vehicle 13 | 1441 |
| Vehicle 14 | 1468 |
| Vehicle 15 | 1385 |



# Any Questions?