Decision Variables

1. x_{ik} : Truck serves customer from warehouse i to k (1 if true, 0 if false)
2. d_{kj} : Drone dispatched from truck at node k to serve customer j (1 if true, 0 if false)
3. y_{ik} : Truck visits node k when serving customers from warehouse i
4. z_{kj} : Drone visits node k when serving customer j
5. $T_{\text{Truck}_{ik}}$: Time by truck from i to k to serve j
6. $T_{\text{Drone}_{kj}}$: Time by drone from k to serve customer j
7. u_{ijk} : Binary variable to mark nodes visited by truck between i and k

Objective Function

$$\text{Minimize:} \quad Z = \alpha_T \sum_{i,k} x_{ik} \cdot C_{\text{Truck}_{ik}} + \alpha_D \sum_{k,j} d_{kj} \cdot C_{\text{Drone}_{kj}} + \lambda \cdot (T_{\text{Truck}_{ik}} + T_{\text{Drone}_{kj}})$$

Constraints

1. $\sum_{k} x_{ik} + \sum_{j} d_{kj} = 1$ (Serve by truck or drone)
2. $T_{\text{Truck}_{ik}} = \frac{\text{Dist}_{\text{Truck}_{ik}}}{\text{Speed}_{\text{Truck}}}$ (Truck Time Constraint)
3. $T_{\text{Drone}_{kj}} = \frac{\text{Dist}_{\text{Drone}_{kj}}}{\text{Speed}_{\text{Drone}}}$ (Drone Time Constraint)
4. $x_{ik} \geq d_{kj}$ (Drone Dispatch Constraint)
5. $\sum_{j} x_{ik} = y_{ik}$ (Mark nodes visited by truck)
6. $\sum_{j} d_{kj} = z_{kj}$ (Mark nodes visited by drone)
7. $u_{ijk} \geq y_{ik} - z_{kj}$ (Mark nodes visited by truck between i and k)

Where:

- x_{ik} is binary, indicating truck serves from warehouse i to k.
- d_{kj} is binary, indicating drone dispatched from truck at k to serve j.
- y_{ik} is binary, indicating truck visits k when serving from i.
- z_{kj} is binary, indicating drone visits k when serving j.
- $T_{\text{Truck}_{ik}}$ is time by truck from i to k to serve j.
- $T_{\text{Drone}_{kj}}$ is time by drone from k to serve j.
- $C_{\text{Truck}_{ik}}$ is cost for truck serving from i to k.
- $C_{\text{Drone}_{kj}}$ is cost for drone serving from k to j.
- α_T is unit variable cost for truck.
- α_D is unit variable cost for drone.
- λ is weight parameter for time in the objective function.