Notation :-

I : Set of location (Depot + Warehouse_customer)

J : Set of customer ($\subseteq I$)

K : Set of all trucks.

C_{ij} : Travel distance btw i & j

t_{ij} : " Time " "

Q_k : max. wt. of truck k can carry.

d_j : Demand (wt.) at location j

a_j : earliest start of time window at location j

b_j : Latest end of time window at j

Decision variable :-

$x_{ijk} \in \{0,1\} = \begin{cases} 0 & , o.w \\ 1 & , \text{truck k travel from i to} \end{cases}$

$t_{jk} \geq 0$: Arrival time of truck k at j

$I_k = \begin{cases} 1 & , \text{if truck k is used} \\ 0 & , o.w. \end{cases}$

Constraint

1 Flow Balancing Constraints:

$$\sum_{k} \sum_{\substack{j \\ j \neq i}} x_{ijk} = \sum_{k} \sum_{j \neq i}^{j} x_{jik} = 1 \quad , \forall i$$

2. Vechicle Capacity Constraints

$$\sum_{\substack{j \in I, \\ j \neq i}} d_j \cdot x_{ijk} \leq Q_k \cdot I_k \quad , \forall k \in K, \forall i \in J$$

3. Depot Constraint

each vechicle must leave the depot onces and return to depot onces.

$$\left.\begin{aligned} \sum_{j \in J} x_{depot,j,k} &= 1 \\ \sum_{i \in J} x_{i,depot,k} &= 1 \end{aligned}\right\} \forall k \in K$$

4. Time Window (Working as sub-tour)

$$a_j \leq t_{jk} \leq b_j \quad , \forall j, k$$

5. Service Time and Travel time Constraint

The time at which trucks arrive at Customer must be after it leaves the Previous location + travel + service time.

$$t_{jk} \geq t_{ik} + s_i + t_{ij} - M(1 - x_{ijk});$$

$\forall i, j \in I$

$\forall k \in K$

M is large constant.

6. Linking Constraint

$$I_k \geq x_{ijk}, \forall i, j \in I$$

$\forall k \in K.$

Objective function :-

1. Minimize total Distance.

$$\text{Min} \sum_k \sum_i \sum_j c_{ij} x_{ijk}$$

2. Minimize total cost (fixed)

$$\text{Min} \sum_k 2 \cdot Q_k \cdot I_k.$$

Cost depends on Capacity.
fixed cost = capacity * 2
Per km cost = 20000 − cj / 1000

3. Min. no of trucks used

$$\text{Min} \sum_k I_k$$