Formulation 1.0

$$
\begin{aligned}
i \in [1, N] &\quad : \quad \text{Charging station location} \\
j \in [1, M] &\quad : \quad \text{Demand hotspot}
\end{aligned}
$$

D_j : Demand (value) at demand hotspot j

$S_{i,j}$: Distance (by road) between station location i and demand hotspot j

G : Maximum number of stations to build in the network ($\leqslant N$)

Other variables used:

L_j : Penalty/Loss incurred by vehicles at i to travel to the assigned station for charging

Decision Variables

$$\alpha_{i,j} = \begin{cases} 1, & \text{if demand hotspot } j \text{ is assigned to station } i \\ 0, & \text{otherwise} \end{cases}$$

$$x_i \;=\; \begin{cases} 0, & \text{if station should be built at location } i \\ 1 & \text{otherwise} \end{cases}$$

Objective Function

$$\text{minimize} \;:\; \sum_{j=1}^{M} D_j \times L_j$$

Constraints

Fractional Demand

$$0 \leqslant \alpha_{i,j} \leqslant x_i \quad \forall i \in 1, 2, \ldots, N, j \in 1, 2, \ldots., M$$

Fractional Demand Sum

$$\sum_{i=1}^{N} \alpha_{i,j} = 1 \quad \forall j \in 1, 2, \ldots., M$$

Distance Penalty Definition

$$\sum_{i=1}^{N} D_{i,j} \times \alpha_{i,j} = L_j \quad \forall j \in 1, 2, \ldots., M$$

Formulation 2.0

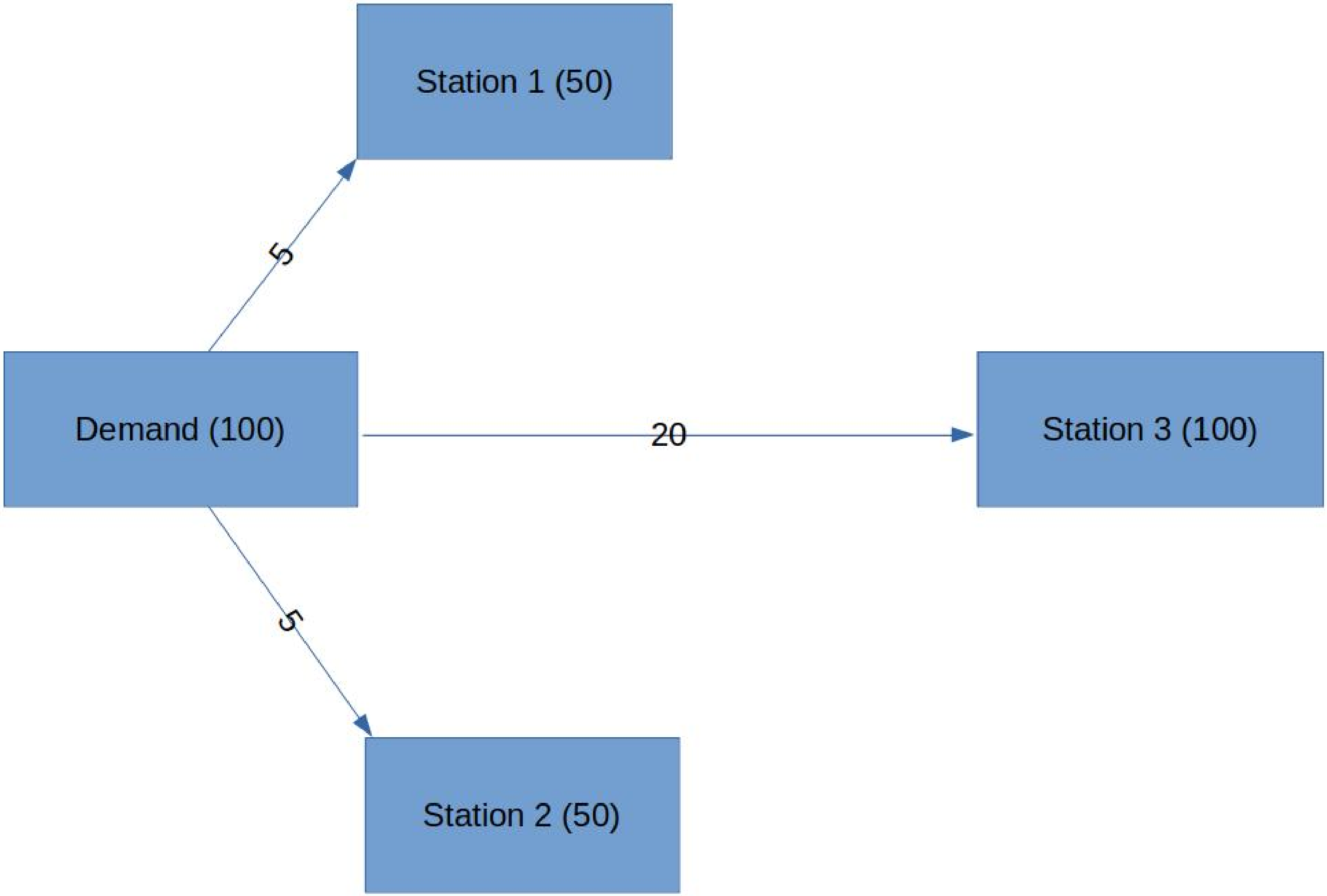
More complexity! New parameters as follows:

$$k \in [1, K] \ \ : \ \ \text{Demand type}$$

$D_{j,k}$: Demand for type k at demand hotspot j
$C_{i,k}$: Capacity of the station at i (if built) for demand type k

New constraints:

$$\sum_{j} D_{j,k} \times \alpha_{i,j} \leqslant c_{i,k} \quad \forall i \in 1, 2, \ldots, N, k \in 1, 2, \ldots., K$$


Station 1 (50)
5
Demand (100)
20
Station 3 (100)
5
Station 2 (50)

With the added capacity constraint, some weird scenarios may happen.

So, we need to allow for **fractional assigning** of demands to make the assignment even more efficient. Thus, α is now defined as:

$$\alpha_{\,i,j} \;:\; \text{Fraction of demand at } j \text{ assigned to station } i$$

Objective function updated to sum over all demand types:

$$\text{minimize} \;:\; \sum_{k=1}^{K} \sum_{j=1}^{M} D_{j,k} \times L_j$$