Project Problem Formulation

Linear Programming (LP) Formulation

The Linear Programming (LP) problem involves minimizing the total delay (objective) while meeting supply and demand constraints across various airports.

Sets

1. O: Set of origin airports (e.g., $\text{BWI, MDW, DAL, DEN, LAS}$)
2. D: Set of destination airports (e.g., $\text{LAX, OKC, SAN, SEA, LGA, CHS, DCA, HNL, MIA}$)

Parameters

- Supply_o: Predicted supply at origin airport o
- Demand_d: Predicted demand at destination airport d
- $\text{Delay}_{o,d}$: Predicted average departure delay (minutes) from origin o to destination d
- $\text{MinMix}_{o,d} = 0.1 \times \text{Supply}_o$: Minimum flight assignment mix for route (o, d)

Decision Variables

- $X_{o,d}$: Number of flights (or assigned units) from origin o to destination d

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Objective Function

Minimize the total delay across all routes:

$$\text{Minimize} \quad Z = \sum_{o \in O} \sum_{d \in D} \text{Delay}_{o,d} \cdot X_{o,d}$$

Constraints

1. Supply Constraints

For each origin airport o, the total assigned amount cannot exceed the predicted supply:

$$\sum_{d \in D} X_{o,d} = \text{Supply}_o \quad \forall o \in O$$

2. Demand Constraints

For each destination airport d, the total assigned amount must meet or exceed the predicted demand:

$$\sum_{o \in O} X_{o,d} \geq \text{Demand}_d \quad \forall d \in D$$

3. Minimum Flight Assignment Mix

For each route (o, d), the number of flights assigned must meet the minimum mix constraint, defined by the 10% of the supply node:

$$X_{o,d} \geq 0.1 \times \text{Supply}_o \quad \forall (o, d)$$

4. Integrality Constraints

The decision variables must be integers:

$$X_{o,d} \in \mathbb{Z} \quad \forall (o, d)$$

LP Formulation Summary

$$\text{Minimize:} \quad Z = \sum_{o \in O} \sum_{d \in D} \text{Delay}_{o,d} \cdot X_{o,d}$$

Subject to:

1. $$\sum_{d \in D} X_{o,d} = \text{Supply}_o \quad \forall o \in O$$
2. $$\sum_{o \in O} X_{o,d} \geq \text{Demand}_d \quad \forall d \in D$$
3. $$X_{o,d} \geq 0.1 \times \text{Supply}_o \quad \forall (o, d)$$
4. $$X_{o,d} \in \mathbb{Z} \quad \forall (o, d)$$
