ISEN 601
Location Logistics
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Transportation

• Trends
Transportation

• Some terms

  • **FTL:** full truck-load → charged per unit distance
  • **LTL:** less-than-truckload → charged per unit

  \[ \Rightarrow \text{cost} \propto \text{distance} \]

  \[ \Rightarrow \text{cost} \propto \text{amount} \propto \text{distance} \]

Transportation

• Transportation by type

  Cost / ton-mile

  • **Air:** \$0 /ton-mile
  • **FTL:** \$1 /ton-mile
  • **LTL:** \$5 /ton-mile

  \( \text{(or} \ 2000) \)
Types of Transportation Paths

- **Direct Shipment:**

  \[ \text{Capacity (c_i)} \rightarrow \text{Retailers (R_j)} \rightarrow \text{Demand (d_i)} \]

  \[ c \rightarrow \text{Retailers (R)} \rightarrow d \]

  \[ a_i j \text{ (cost per unit per unit distance) x} \]

  \[ n \text{ retailers} - j \]

  \[ m \text{ suppliers} - i \]

  \[ x_{ij} = \text{amount of product supplied from } i \text{ to } j \]

Direct Shipment

- **Math formulation:**

  \[ \min \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij} \]

  \[ s.t. \text{ "capacity" } \sum_{j=1}^{n} x_{ij} \leq c_i, \forall i \]

  \[ \text{ "demand" } \sum_{i=1}^{m} x_{ij} \geq d_j, \forall j \]

  \[ x_{ij} \geq 0, \forall i, \forall j \]
Direct Shipment

- When to use?

Improvements to Direct Shipment

- Option 1: Crossdocking

how to merge multi products

*keeps FTLs*
Improvements to Direct Shipment

- Option 2: DC
  - Custom packaging (Dell)
  - Customization
  - Transportation
  - Logic doesn't change

Improvements to Direct Shipment

- Option 3: Delivery rounds / TSP
  - Travelling salesman problem
  - Set of n locations \( \{1, 2, \ldots, n\} \)
  - Travel costs \( c_{ij} \)
  - Decision variables:
    - \( y_{ij} = 1 \) if we go \( i \to j \)
    - \( y_{ij} = 0 \) otherwise
  - Visit all locations
  - Return to starting point
Traveling Salesman Problem

- Problem statement:
\[
\min \ \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij}
\]

s.t. \( x_{ij} \in \{0, 1\} \)
leave location \( i \) exactly once \( \sum_{j \neq i} x_{ij} = 1 \) for \( i \in N \)
enter location \( j \) exactly once \( \sum_{i \neq j} x_{ij} = 1 \) for \( j \in N \)

Traveling Salesman Problem

- BIP formulation:
Traveling Salesman Problem

- Subtours:

\[ \text{How can we eliminate} \]

\% don't want this!!

Warehouse Location Problem

- Mixed-integer programming formulation:

\[ \cup_{S \neq \emptyset} \text{SCN, } S \neq \emptyset \]

\[ \sum_{i=1}^{S} x_{ij} \geq 1 \quad \forall \text{SCN, } S \neq \emptyset \]

*Pick a subset \( S \) to take nodes not in subset \( \emptyset \), check that I leave subset-to-nodes at least once.
Dynamic Warehouse Location

- Idea: demands and costs change over time
- Divide up time into discrete periods, 1..T
- Minimize the sum of
  - distribution,
  - location,
  - relocation
  costs over all T periods

Dynamic Warehouse Location

- Decisions:
  - which warehouses to open/close in period t
  - who should supply which customers in period t
- Decision tradeoff:
Dynamic Warehouse Location

• Assumptions:
  • customer locations $j$ (discrete points)
  • facility locations $i$
  • locate up to $m$ facilities each period
  • facilities are uncapacitated

• Costs:

Dynamic Warehouse Location

• Decision variables:
Dynamic Warehouse Location

- MIP:

Dynamic Warehouse Location

- Opening/closing constraints: