Facility Location

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Adapted from P. Keskinocak's lecture notes

What is a “Facility”?

Factors influencing location decision

- Locations of customers
- Location of suppliers
- Transportation access
- Real estate costs
- Material costs
- Cost of labor

Expansion capability
Local political conditions
Climate
Weather events
Insurance costs
Locations of competitors

How hard can the decision be?

Customer locations and demand:

A: (2.0, 2.9), 520 units

B: (3.1, 2.5), 800 units

C: (1.8, 2.2), 540 units

D: (2.4, 1.7), 1,550 units

E: (0.5, 1.6), 790 units

F: (1.7, 0.6), 1,260 units

G: (3.3, 1.4), 2,050 units

Decision

Where to locate the distribution center ?

Performance measure: weighted distance from customers (center-of mass)

How to measure distance?

Measuring Distances

- "Manhattan distance" (1-norm)
  - Best for cities with perpendicular streets
  - N-S distance + E-W distance

$$L_1 = |x_1 - x_2| + |y_1 - y_2|$$

- "As the crow flies" (2-norm)
  - Best for long distances and highways

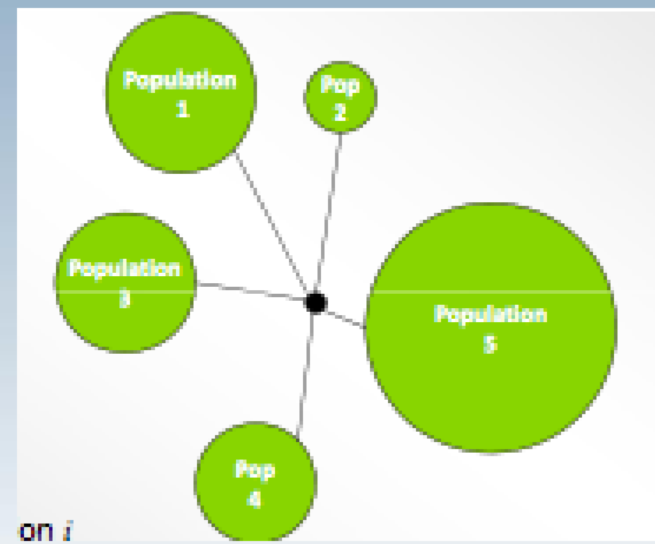
$$L_2 = \sqrt[2]{(x_1 - x_2)^2 + (y_1 - y_2)^2}$$

- Larger of N-S and E-W distances (∞-norm)
  - Useful for automatic warehouses

$$L_\infty = \max(|x_1 - x_2|, |y_1 - y_2|)$$

Center-of-mass

- Center-of-mass location = The weighted average location of a set of populations
- Weights can be:
  - Population size
  - Demand
  - Importance
  - Severity of need



$$(\bar{x},\bar{y}) = \frac{\sum_i d_i (x_i, y_i)}{\sum_i d_i}$$

d_i = weight of population i
x_i = x-coordinate of population i
y_i = y-coordinate of population i

Example

- Center of Mass:

$$\bar{x} = \frac{x_A d_A + x_B d_B + x_C d_C + x_D d_D + x_E d_E + x_F d_F + x_G d_G}{d_A + d_B + d_C + d_D + d_E + d_F}$$

$$\bar{x} = \frac{x_A d_A + x_B d_B + x_C d_C + x_D d_D + x_E d_E + x_F d_F + x_G d_G}{d_A + d_B + d_C + d_D + d_E + d_F + d_G}$$

$$= \frac{(2.0*520)+(3.1*800)+(1.8*540)+(2.4*1550)+(0.5*790)+(1.7*1260)+(3.3*2050)}{520+800+540+1550+790+1260+2050}$$

$$= 2.3$$

$$\bar{y} = \frac{(2.9*520)+(2.5*800)+(2.2*540)+(1.7*1550)+(1.6*790)+(0.6*1260)+(1.4*2050)}{520+800+540+1550+790+1260+2050}$$

$$= 1.6$$

Example (cont.)

- Least-distance facility located at (2.3, 1.6)
- What could be wrong with this location?
  - Cost of land
  - Availability of land
  - Traffic congestion to/from facility
  - No information about tax structure
  - Zoning

Example (cont.)

Candidate locations, costs:

1: (2.3, 1.6), \$30M + \$50/unit

2: (1.3, 2.5), \$15M + \$40/unit

3: (1.9, 3.7), \$12M + \$30/unit

4: (3.7, 3.2), \$15M + \$35/unit

5: (0.8, 0.3), \$10M + \$40/unit

Assumptions:

- Travel costs are \$1/mile-unit
- Demand fulfilled weekly
- Each unit square is 8x8 miles

So

- Decisions to make:
  - Whether to open each candidate location?
  - How much to ship to each customer from each opened facility
- We need Optimisation models to find the "best" location (IE202)
- How about simplified versions?

Representation by networks

- Graphical representation
- Nodes (vertices) + arcs (edges)