

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
- “As the crow flies” (2-norm)
 - Best for long distances and highways
- Larger of N-S and E-W distances (∞ -norm)
 - Useful for automatic warehouses

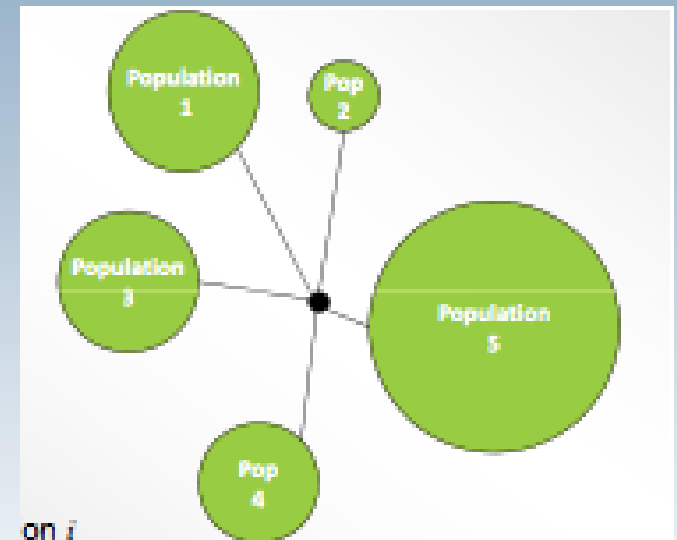
$$L_1 = |x_1 - x_2| + |y_1 - y_2|$$

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

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

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:

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

$$\begin{aligned}\bar{x} &= \frac{x_A d_A + x_B d_B + x_C d_C + x_D d_D + x_E d_E + x_F d_F + x_G d_G}{d_A + d_B + d_C + d_D + d_E + d_F + d_G} \\ &= \frac{(2.0 * 520) + (3.1 * 800) + (1.8 * 540) + (2.4 * 1550) + (0.5 * 790) + (1.7 * 1260) + (3.3 * 2050)}{520 + 800 + 540 + 1550 + 790 + 1260 + 2050} \\ &= 2.3 \\ \bar{y} &= \frac{(2.9 * 520) + (2.5 * 800) + (2.2 * 540) + (1.7 * 1550) + (1.6 * 790) + (0.6 * 1260) + (1.4 * 2050)}{520 + 800 + 540 + 1550 + 790 + 1260 + 2050} \\ &= 1.6\end{aligned}$$

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)

