

# Lecture #32

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Service Processes & Systems  
Dept. of Mechanical Engineering - Engineering Mechanics  
Michigan Technological University

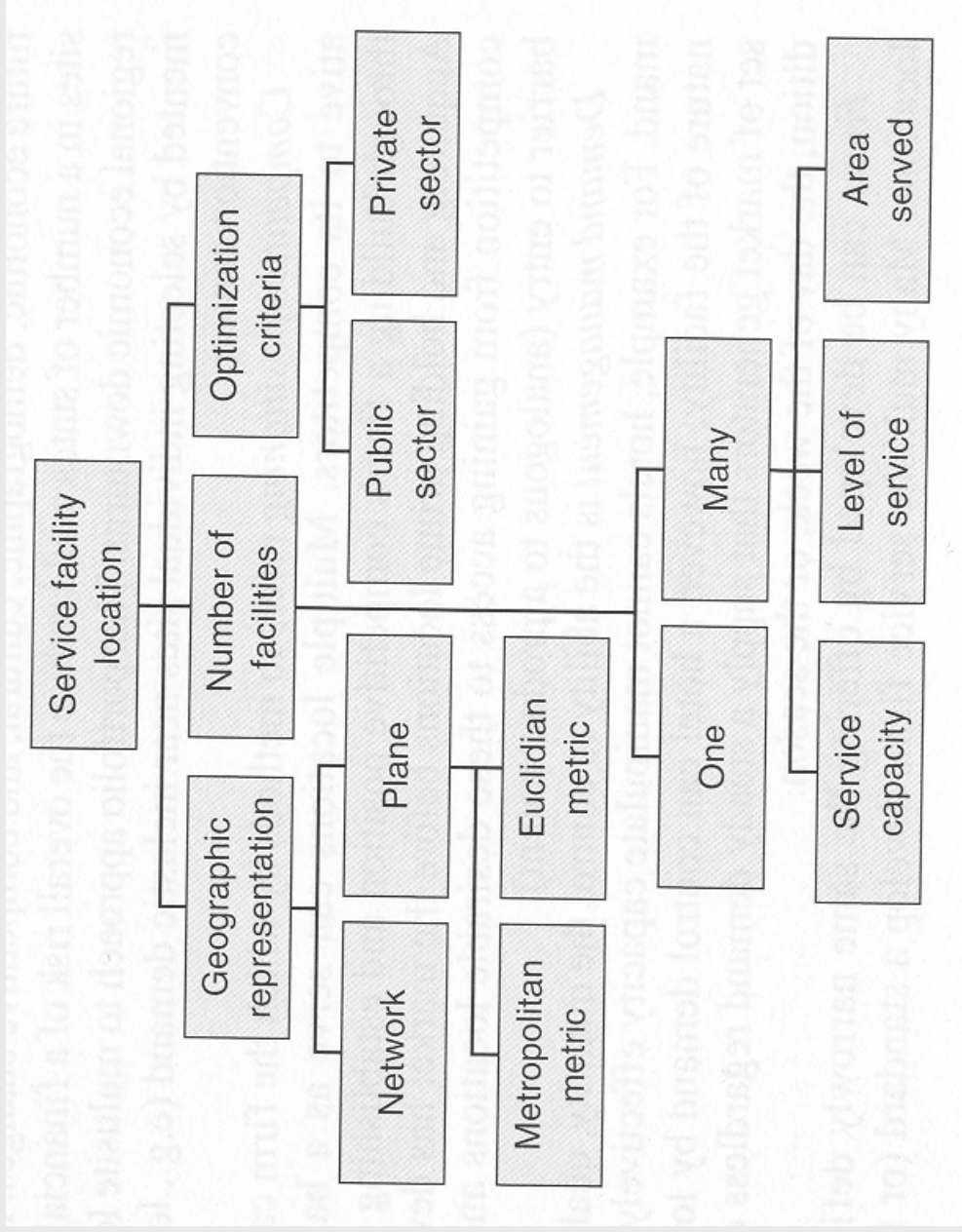
# So far...

- ❖ Last several classes – talked about the importance of forecasting and different forecasting methods
- ❖ Short term forecasting – useful in day-to-day business operation
- ❖ Long term forecasting – useful when trying to design & locate service facility
- ❖ Today – discuss some techniques to efficiently locate service facilities.

# Service Facility Location Planning

- ❖ **Competitive positioning:**
  - ❑ Lack of a prime location – can be a barrier to entry.
- ❖ **Demand management:**
  - ❑ Location can influence markets.
- ❖ **Flexibility:**
  - ❑ Plan for future economic changes and portfolio management.
- ❖ **Expansion strategy:**
  - ❑ Contiguous to existing site → or to new regional site. Distributed vs. concentrated

# Location Considerations



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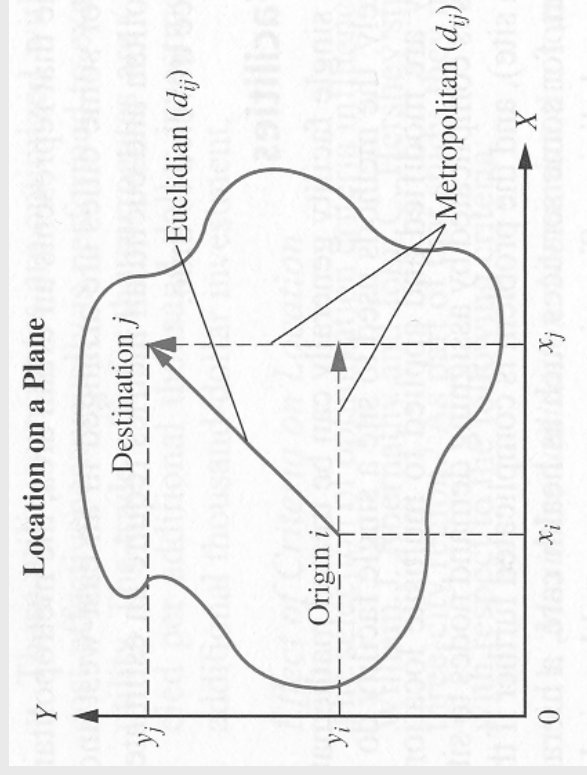
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# Geographic Representation

- ❖ The traditional classification of location problems is based on how the geography is modeled.
- ❖ Location options and travel distance can be represented on either a plane or a network.
- ❖ Location on a plane (i.e., flat surface) is characterized by a solution space that has infinite possibilities.

# Geographic Representation – Plane

- ❖ A facility (origin) may be located anywhere on the plane – characterized by an X-Y coordinate.
- ❖ Destinations are to be served by the facility site



# Planar Representation

❖ Euclidian distance between facility and each location is

$$d_{ij} = \left[ (x_i - x_j)^2 + (y_i - y_j)^2 \right]^{1/2}$$

- ❑  $d_{ij}$  = distance between points i and j
  - ❑  $x_i, y_i$  = unknown coordinates of the facility
  - ❑  $x_j, y_j$  = coordinates of the jth location
- ❖ Want to select  $(x_i, y_i)$  to minimize:

$$S = \sum_{j=1}^n d_{ij}$$

# Euclidian Distance

❖ S is minimized if facility  $(x_i, y_i)$  is placed at the centroid of the destinations.

$$x_i = \sum_{j=1}^n x_j$$

$$y_i = \sum_{j=1}^n y_j$$

# Metropolitan Distance

- ❖ Distance may also be measured with metropolitan metric – vertical and horizontal travel distances (i.e., north-south and east-west travel in urban areas):

$$d_{ij} = |x_i - x_j| + |y_i - y_j|$$

$$S = \sum_{j=1}^n d_{ij}$$

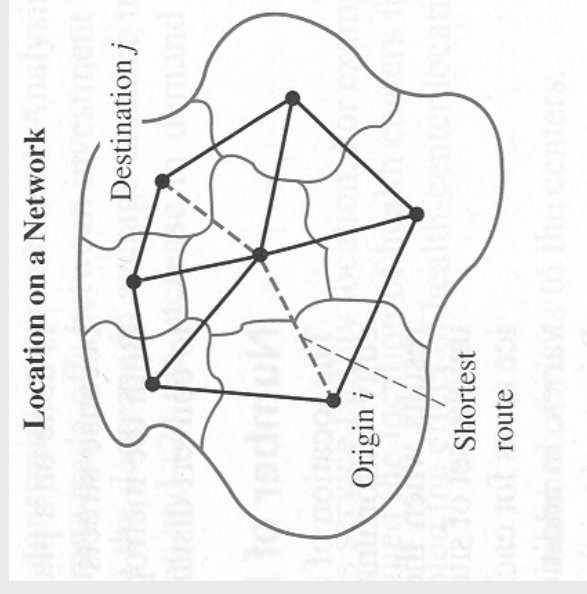
# Metro Distance

- ❖ S can be minimized – facility location  $(x_i, y_i)$  found – numerically.
- ❖ Numerical solution can be obtained using "solver" function, for example, in MS Excel.

# Geographic Representation – Network

❖ Location on a network is characterized by a solution space that is restricted to the nodes of that network.

- ❑ e.g. a highway system could be considered a network, with major highway intersections as nodes.
- ❑ The arcs of the network represent travel distance of (or time) between pairs of nodes, calculated using the shortest route.



# Optimization Criteria

- ❖ Private and public sector location problems are similar in that they share the objective of maximizing some measure of benefit. The location criteria that are chosen differ, however, because the “ownership” is different.
- ❖ Within the private sector, the location decision is governed by either minimization of cost (e.g., in the case of distribution centers) or maximization of profit (e.g., in the case of retail locations).
- ❖ In contrast, we like to think that public facility decisions are governed by the needs of society as a whole. The objective for public decision making is to maximize a societal benefit that may be difficult to quantify.

# Private Sector Criteria

- ❖ It focuses on a trade-off between the cost of building and operating facilities and the cost of transportation.
- ❖ When the consumer travels to the facility, no direct cost is incurred by the provider. Instead, distance becomes a barrier restricting potential consumer demand and the corresponding revenue generated.

# Public Sector Criteria

- ❖ Because the benefits of a public service are difficult to define or quantify directly, surrogate (or substitute) measures of utility are used.
- ❖ The average distance traveled by users to reach the facility is a popular surrogate.
- ❖ The smaller this quantity, the more accessible the system is to its users. Thus, the problem becomes one of minimizing the total average distance traveled, with a constraint on the number of facilities.
- ❖ Another possibility is the creation of demand. Here the user population is not considered fixed but is determined by the location size, and number of facilities.

# Effect of Criteria on Location

❖ The selection of optimization criteria influences service facility location.

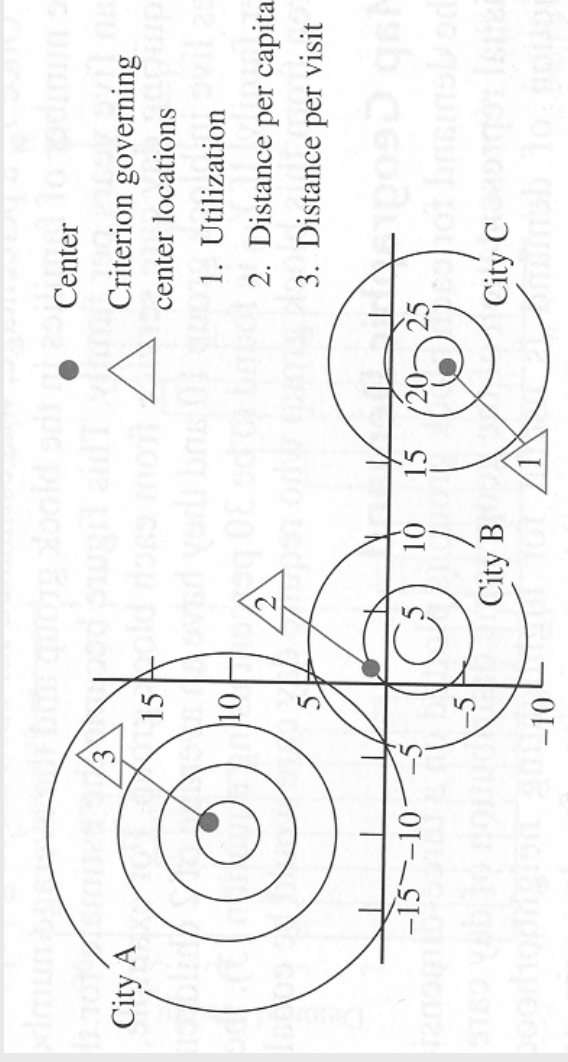
□ e.g., Abernathy and Hershey studied the location of health centers for a 3-city situation. As part of the study, they noted the effect of health-center locations with respect to the following criteria:

- Maximize utilization
- Minimize distance per capita
- Minimize distance per visit

# Effect of Criteria on Location

- ❖ The problem was structured so that each city had a population with a different mix of health care consumption characteristics.
- ❖ These characteristics were measured along two dimensions:
  - The effect of distance as a barrier to health care use.
  - The utilization rate at immediate proximity to a health care center.

# Effect of Criteria on Location



- ❖ For criterion 1, the center is C because the city contains a large number of elderly individuals for whom distance is a strong barrier
- ❖ City B is selected under criterion 2 because this city is centrally located between two large cities.
- ❖ City A is the largest population center and has the most mobile and frequent users of health care, so criterion 3 is selected.

# Estimation of Geographic Demand

❖ This requires the selection both of some geographic unit that partitions the area to be served and of some method for predicting demand from each of these partitions

- ❑ Define the target population
- ❑ Select a unit of area

# Example

- ❖ Demographic data on residents were analyzed statistically using linear regression to develop the following equation, which predicts the % of AFDC (Aid to Families with Dependent Children) for each group of interest.
- ❖ Need this info to site day care facility

# Example

$$\diamond Y_i = 0.0043X_{1i} + 0.0248X_{2i} + 0.0092X_{3i}$$

$\diamond$  Where,

- $\square Y_i$  = % of AFDC families in block group  $i$
- $\square X_{1i}$  = % of persons in block group  $i$  who are under 18 and living in a housing unit with more than 1.5 persons per room
- $\square X_{2i}$  = % of families in block group  $i$  with a single male head and children younger than 18 years
- $\square X_{3i}$  = % of families in block group  $i$  with a single female head and children younger than 18 years.

# Example

- ❖ Once  $Y_i$ , a percentage, is found for each group, multiply by number of families in the group and the average number of children 5 years of age or younger per family.
- ❖ This figure estimates the number of children requiring day care service each group.
  - Assume that 50 families live in group 10 and they have an avg. of 2 children younger than 5 years per family. If  $Y_{10}$  is found to be 30% using the equation, then the estimate of children for this group:  $(0.30)(50)(2) = 30$ .
- ❖ Now, with knowledge of childcare demand & their locations – can site daycare facility.