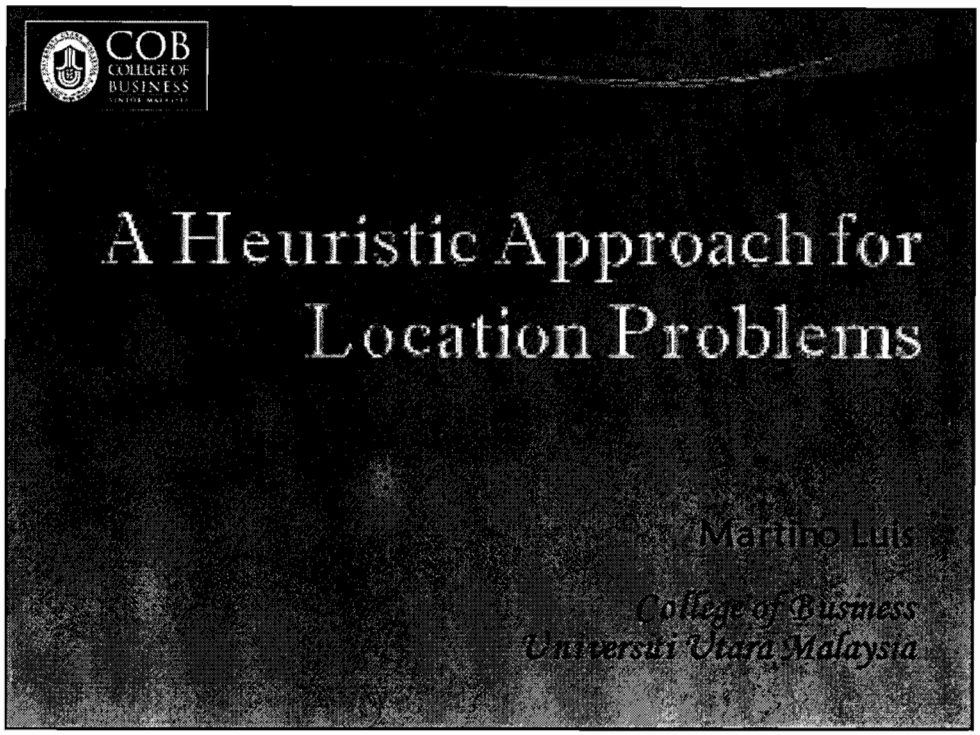


Outline

- **Introduction**
- **Classes of Location Problem**
- **Taxonomy of Location Problems**
- **Problem Description/ Formulation**
- **Solution Methods: Heuristics**
- **Future Investigations**

Introduction

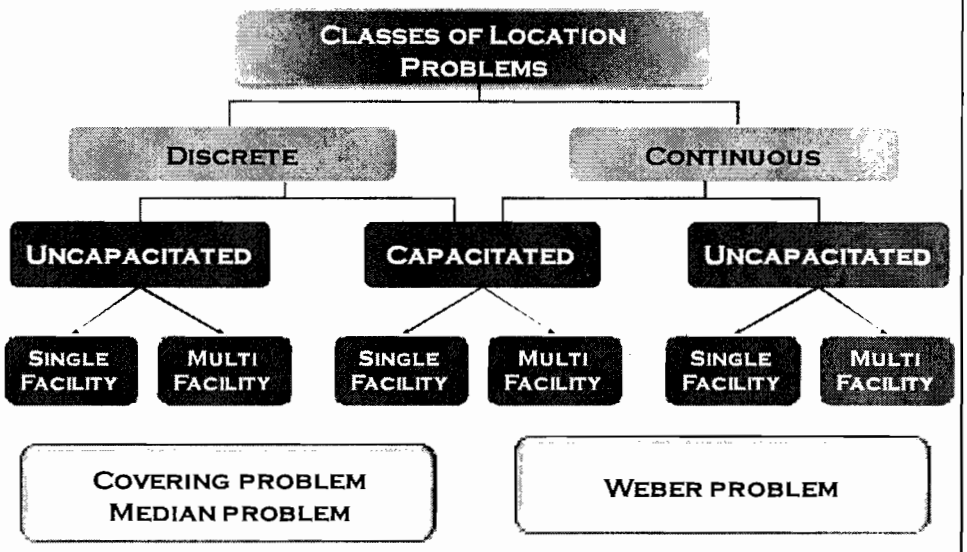
Location analysis is concerned with determining the location of one/more facilities either on a plane or a network with respect to a set of existing facilities so as to perform one or more criteria as an objective function

Introduction

The typical criteria may include:

- *minimizing average travel time or distance between origins and destinations,*
- *minimizing average response time,*
- *minimizing a cost function of travel or response time,*
- *minimizing maximum travel time, or*
- *maximizing minimum travel time*

Classes of Location Problems: Basic



See Hamacher and Nickel (1998) and Daskin (2008)

General Questions

- *How many facilities should be built?*
- *Where should these facilities be?*
- *What should the size of the facility be?*
- *How should demand be allocated?*

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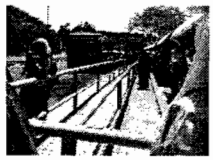
- *Where should these facilities be?*
- *What should the size of the facility be?*
- *How should demand be allocated?*

The answers depend intensively on the perspective of what is the purposes and what are the aims embedded on the goal.

Taxonomy of Location Problems (1)

DISCRETE LOCATION PROBLEMS

PUBLIC SECTORS



- police stations
- fire stations
- Ambulances, etc.
- In a small scale example is bus stops in UUM

The facilities are sited as near as possible to the demand points

Taxonomy of Location Problems (2)

DISCRETE LOCATION PROBLEMS

LOCATING OBNOXIOUS (UNDESIRABLE) FACILITIES

- Nuclear power plants
- Toxic dumps, solid waste repositories
- pollution producing industrial plants, etc.

↳ *the locations would tend to be as far as possible from resident dwelling centres.*

↳ *A possibility of damage property and/or loss of life*

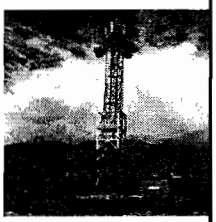
Taxonomy of Location Problems (3)

DISCRETE LOCATION PROBLEMS

PRIVATE SECTORS

manufacturing / service companies:

- production and/ or assembly plants,
- distribution centres
- retail outlets.
- Base transceiver station
- Banks
- Courier agencies

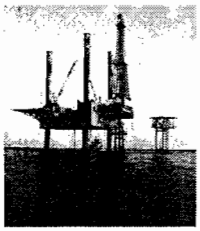


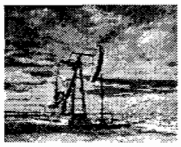
Erroneous location decisions in this circumstance will increase costs and decrease competitive advantages of the company

Taxonomy of Location Problems (4)

CONTINUOUS LOCATION PROBLEMS

- Location of oil drills in the sea or the desert
- Space Satellites



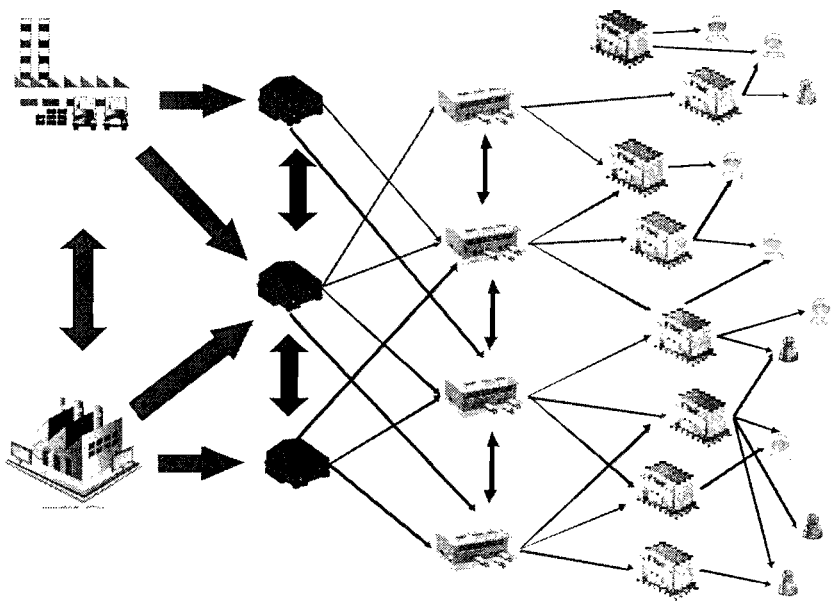

Importance of Location Analysis (1)

- The viewpoint of
  Producers
  → Reduce the operating cost and give more benefits
  Customers
  → obtain advantages, such as lower prices, better quality products and services

- The number of facilities to be located and the size of the individual facilities
  → *the trade off between the service and the cost*

- Facility location decisions also consider how to accommodate *various demand allocation* policies

Importance of Location Analysis (2)



Importance of Location Analysis (3)

- However, location analysis is not always concerned with large scale enterprises such as factories or warehouse locations
- *In the small scale units* such as
  - the location of machines within a production centre
  - the location of a router in a computer network
  - the location of components on a printed circuit board
  - the location of electrical safety devices on electrical network
  - the location of lecture classes within the university

Problem Description

To determine

- the number of facilities to open (public/private sectors),
- the locations (continuous/ discrete), the sizes, and
- the allocation of the customers to each of these open facilities.

  → so that total transportation costs are minimised

- ***Given:***
  - The location of each customer point/ coordinate
  - The demand of every customer point
  - The transportation cost for the area of interest
  - The number of facilities to be opened

Problem Description: Formulation

$$Minimise \sum_{i=1}^{M}\sum_{j=1}^{n} x_{ij} d(X_i, a_j) \qquad (1)$$

Subject to

$$\sum_{i=1}^{M} x_{ij} = w_j, \qquad j = 1, \ldots, n \qquad (2)$$

$$\sum_{j=1}^{n} x_{ij} \le b, \qquad i = 1, \ldots M \qquad (3)$$

$$x_{ij} \ge 0, \qquad i = 1, \ldots M; j = 1, \ldots, n \qquad (4)$$

Solution Techniques

Exact methods

- It is advantageous when a problem is relatively small
- When the size of the problem increases, the computational time will grow exponentially

Heuristic Approaches

- **Do not guarantee optimality** but have the ability to produce ***near optimal solutions*** to difficult optimization problems in a reasonable amount of time

Heuristic Techniques: Definition

- Reeves and Beasley (1993, p. 6) define heuristic as:

  "A heuristic is a technique which seeks good (i.e. near optimal) solutions at a reasonable computational cost without being able to guarantee either feasibility or optimality, or even in many cases to state how close to optimality a particular feasible solution is"

- Heuristic procedures are based on common sense, logic and experience
- They are capable of producing more than ***one single solution*** to the problem since they are easy to understand and to modify
- Interface in Artificial Intelligence and Operational Research

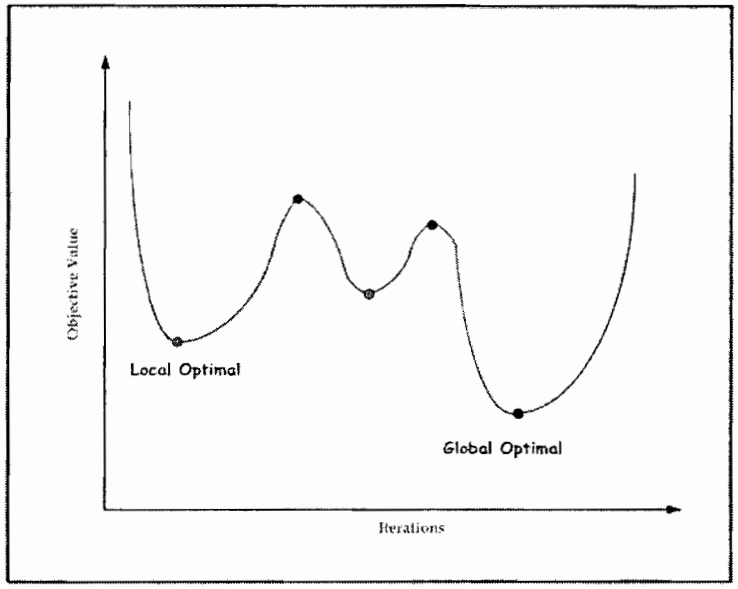
Heuristic Techniques: Not limited to

- **Heuristics** (Osman & Laporte,1996, Salhi, 2006)
  Constructive (descent/ perturbation/ multiphase approaches)
- **Metaheuristics** (Glover & Kochenberger, 2003)
  - Local search (tabu search, simulated annealing)
  - Population/ evolutionary based (*genetic algorithms, ant colony system, bee colony, particle swarm optimisation*)
  - Multistart Search (*greedy randomized adaptive search procedure*)
  - Neighbourhood Search *(Variable Neighbourhood Search)*
  - Mathematical based (*lagrangian heuristic*)
  - Human/ graphical interaction (*neural networks*)
- **Hyperheuristics** (Burke et al. 2009, Ozcan et al. 2008)
  Use (meta) heuristics to choose (meta) heuristics

A Basic Framework of Heuristics

- Step 1: Find an ***initial solution*** S and compute its objective value $C(S)$
- Step 2: While there is an untested neighbour $S' \in$, do the following ***(improvment phase)***:
  - Generate sequentially a trial $S' \in$ and compute $C(S')$
  - If $C(S') < C(S)$ then replace S as a current solution. Otherwise, retain S and repeat Step 2
- Step 3: ***Terminate the search*** and return S as the final solution

Searching Solutions



Heuristic is Heuristic

HEURISTICS

- A basin of Solutions
- Trap in a local optima

METAHEURISTICS

- A pool of Solutions
- Intelligently combining exploring the search space and learning strategies

HEURISTICS

A Science of Tomorrow.

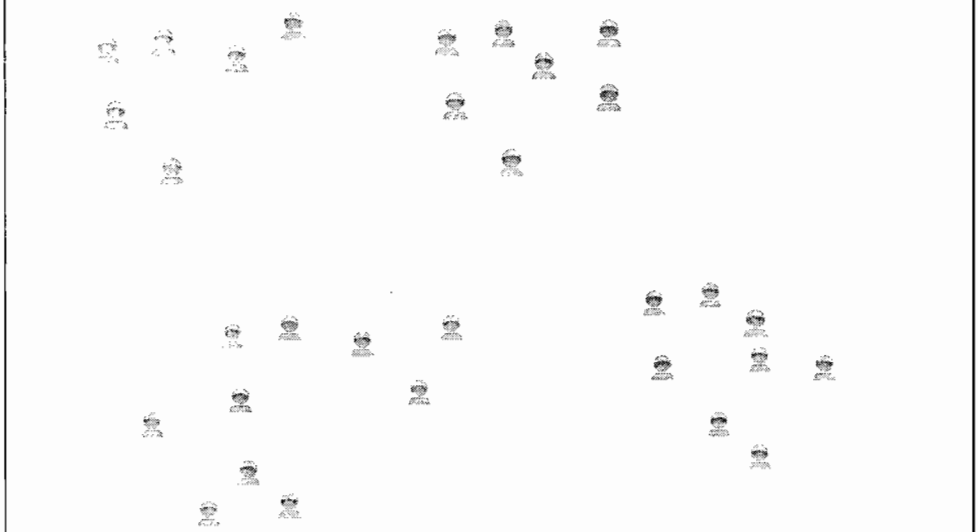
HYPERHEURISTICS

- Use/start with a set *H of (meta) heuristics*
- *Improvements made by applying simple refinement heuristics or metheuristics*
- *Easier and cheaper to implement*

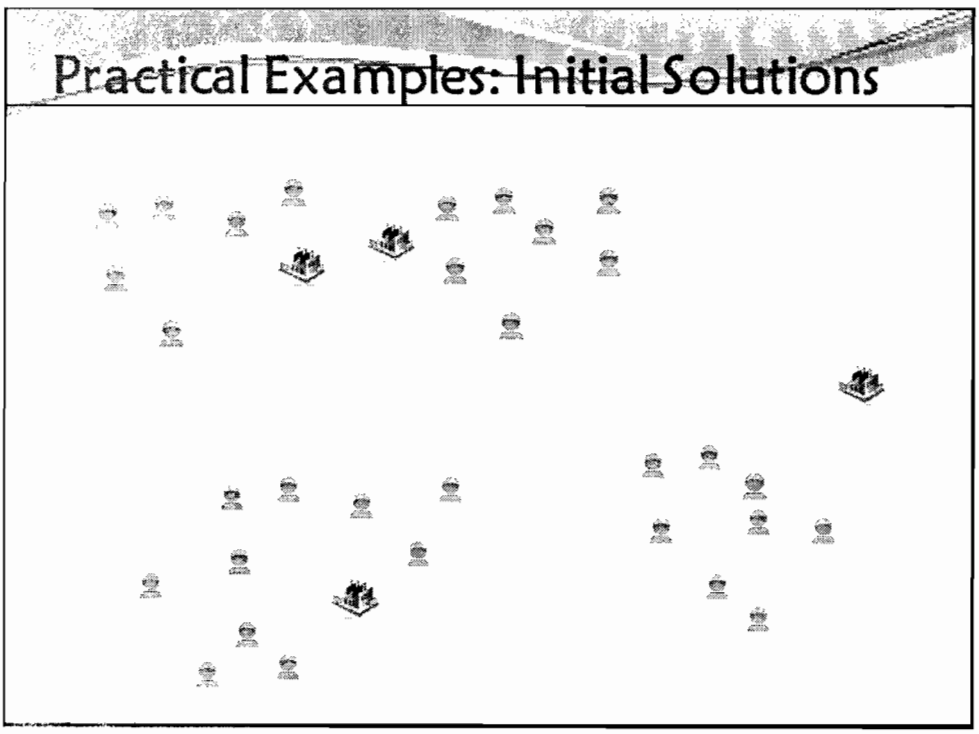
see Salhi (2006) & Burke et al. (2009) for more details

Practical Examples

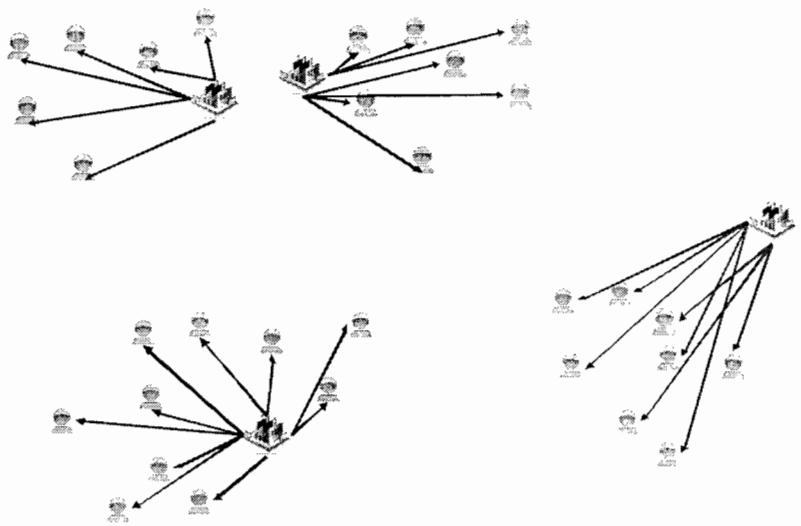
- *Construct 4 facilities*
- *The objective is to minimise total transportation costs*



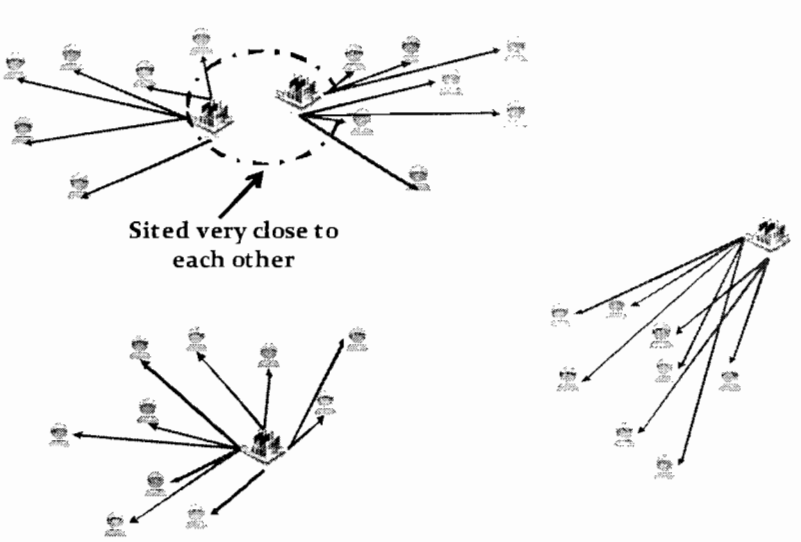
Practical Examples: Initial Solutions



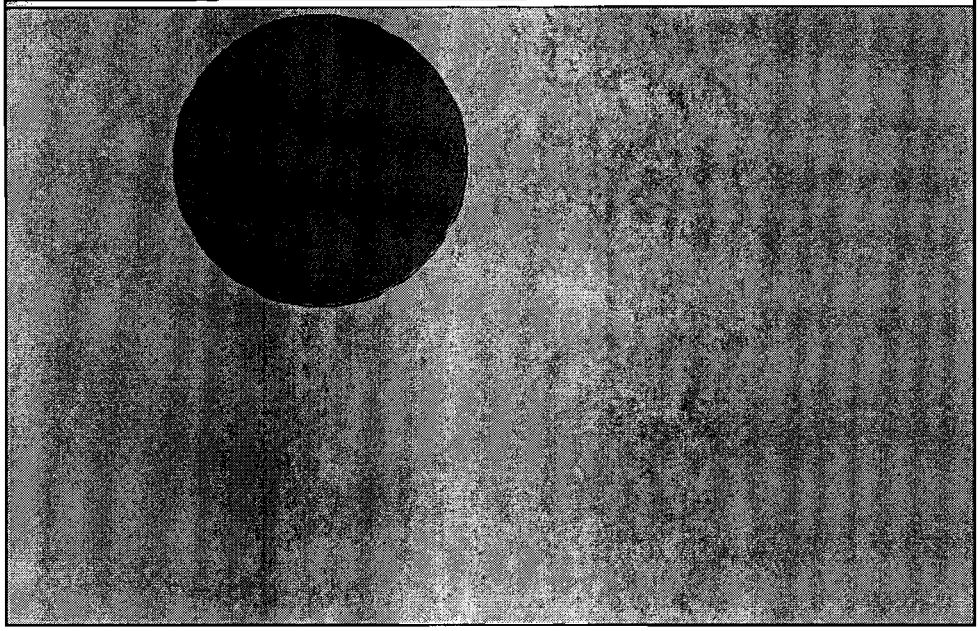
Practical Examples: Initial Solutions



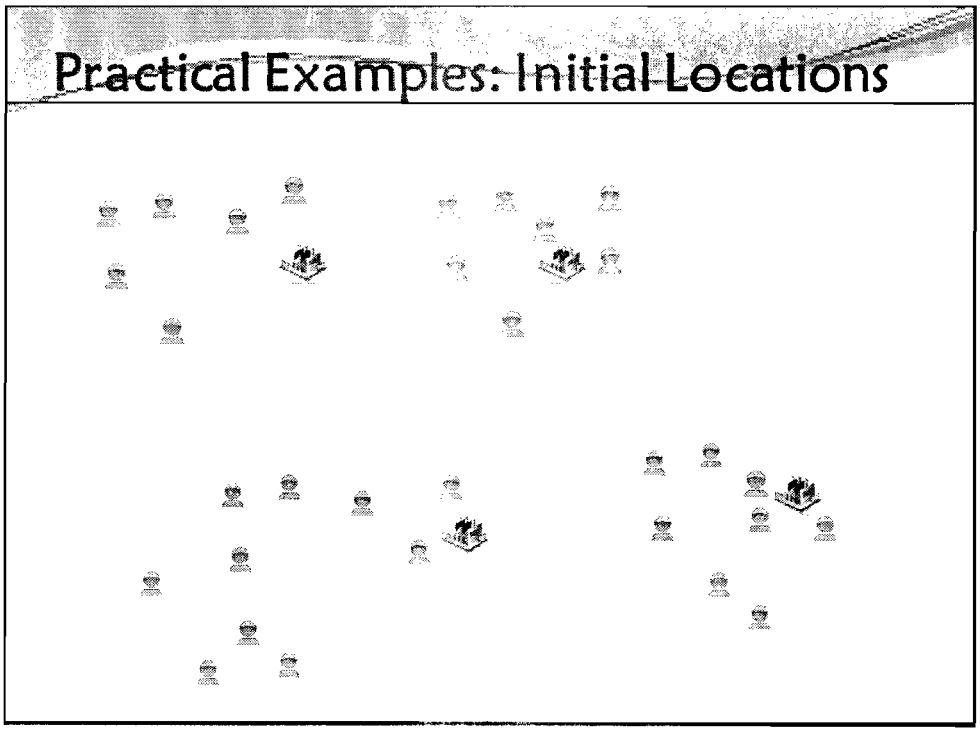
Practical Examples: Initial Solutions



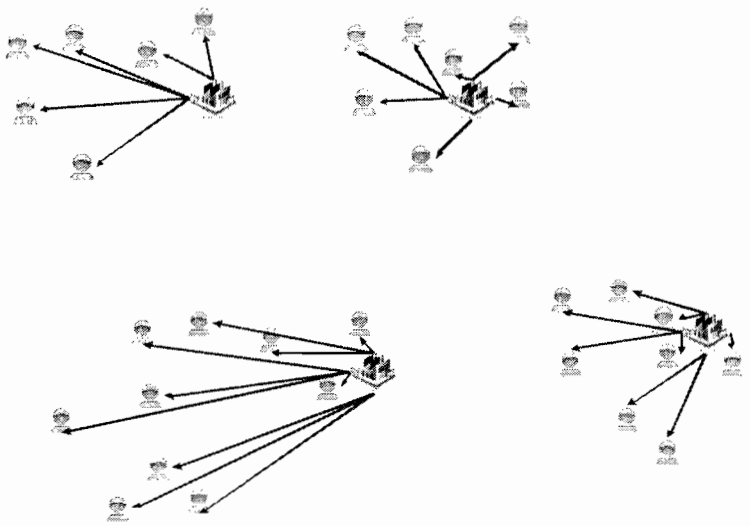
Practical Examples: A guided



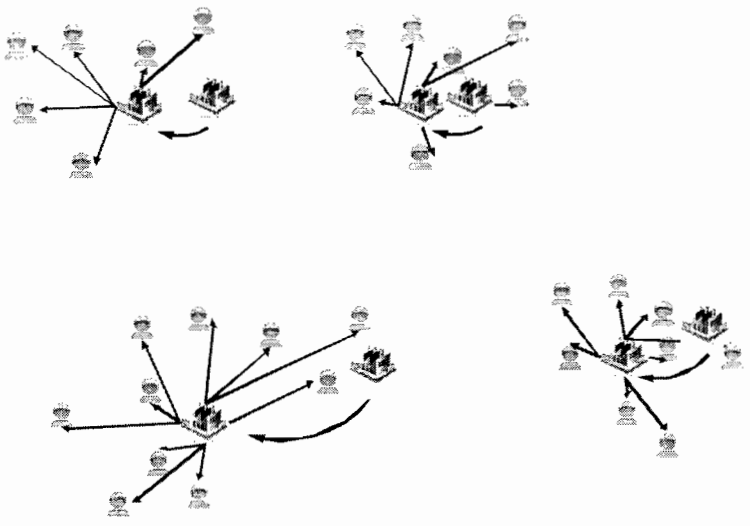
Practical Examples: Initial Locations



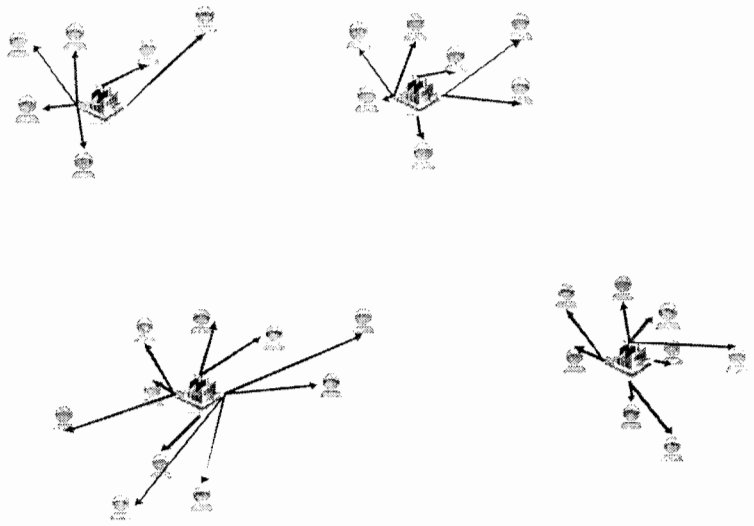
Practical Examples: Improvements



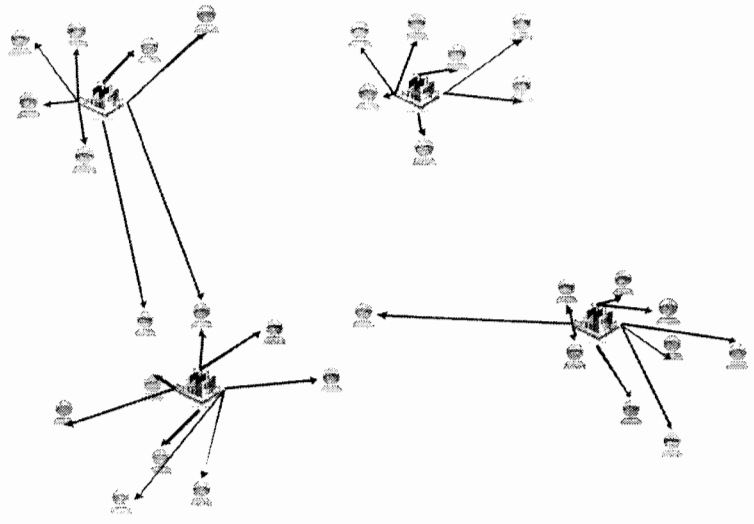
Practical Examples: Improvements



Practical Examples: Improvements



Practical Examples: "Hot" Issues



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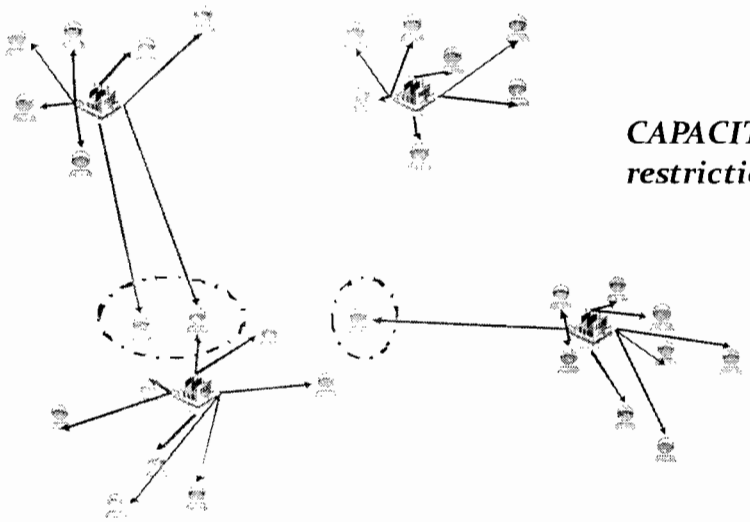
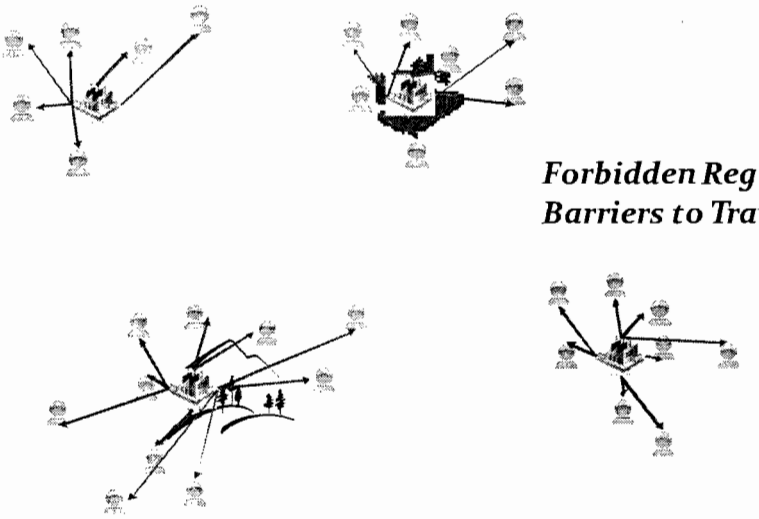


CAPACITY restrictions

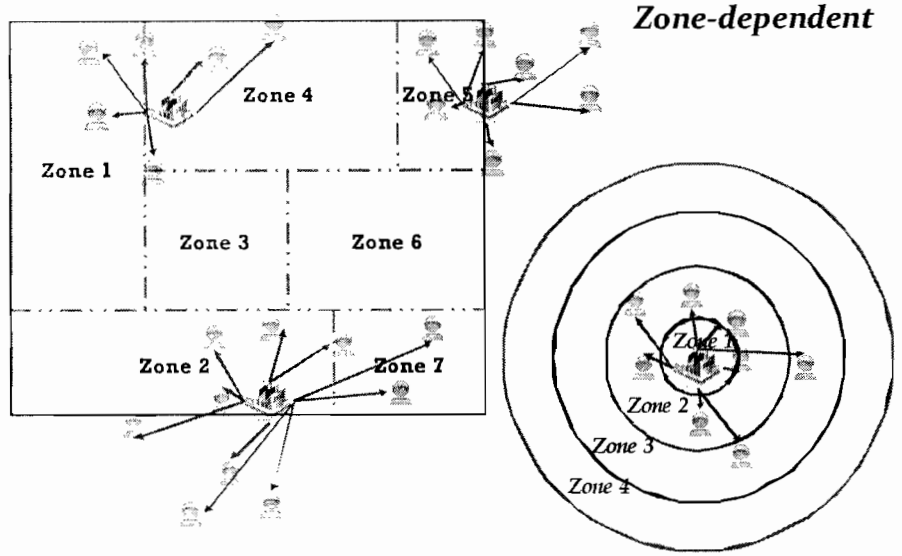
Practical Examples: "Hot" Issues



Forbidden Regions/ Barriers to Travel

Practical Examples: "Hot" Issues

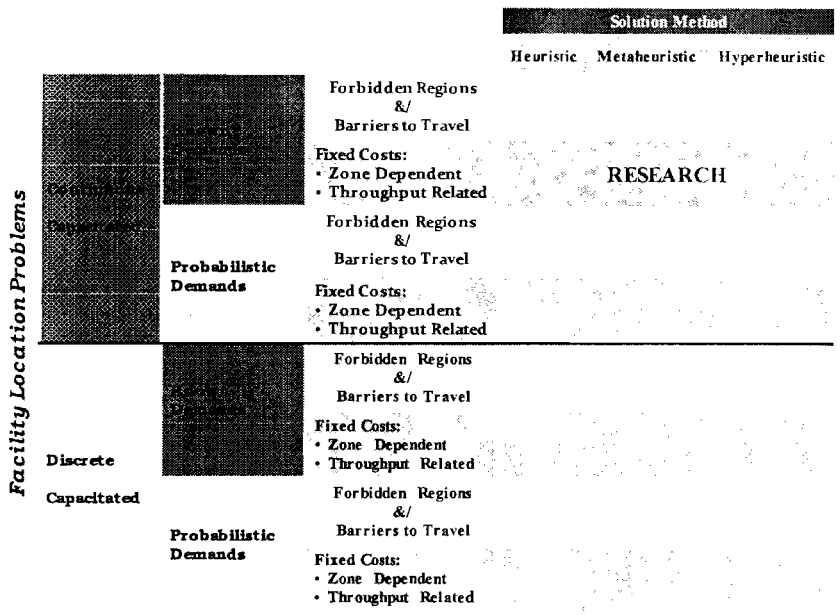
Fixed Costs: Zone-dependent



Future Investigations (1)

Facility Location Problems				Solution Method: Exact Methods	Solution Method: Heuristic	Solution Method: Meta-heuristic
	Continuous	Uncapacitated	No Fixed Cost	Kuenne & Soland (1972), Ostresh (1973, 1975), Love & Morris (1975), Drezner (1984), Rossing (1992), Brimberg & Love (1998)	Cooper (1964), Sullivan & Peters (1980), love & Juel (1982), Murtagh & Niwattisyawong (1982), Chen (1983), Bogartz, Calamai, & Conn (1994), Hansen et al. (1998), Lozano et al. (1998), Gamal & Salhi (2001), Taillard (2003), Hsieh & Tien (2004), Aras et al. (2006)	Liu, Kao, & Wang (1994), Brimberg & Mladenović (1996a, 1996b), Houck, Jones, & Kay (1996), Ohlemüller (1997), Brimberg et al. (2000), Salhi & Gamal (2003)
			Fixed Cost	Brimberg & Salhi (2005)	Brimberg, Mladenović, & Salhi (2004) Brimberg & Salhi (2005)	
			Forbidden Regions & Barriers to Travel	Larson and Sadiq (1983), Batta, Ghose, & Parlekar (1989), Aneja & Parlar (1994), Klamroth (2004), Pfeiffer & Klamroth (2005)	Katz & Cooper (1981), Hansen, Peeters, & Thisse (1982), Hamacher & Nickel (1995), Butt & Cavalier (1996), Hamacher & Klamroth (2000), Klamroth (2001a, b), McGarvey & Cavalier (2003), Klamroth (2004)	Bischoff & Klamroth (2007) Canbolat &Wesolowsky (2010)
		Capacitated		Cooper (1972), Sherali et al. (1994, 2002)	Cooper (1972), Zainuddin & Salhi (2006), Aras, Orbay & Altinel (2006), Aras, Altinel & Orbay (2007), Luis et al. (2009)	Gong et al. (1997) Luis et al. (2011)
	Discrete	Capacitated		Sa (1969), Davis & ray (1969), Akinc & Khumawala (1977), Beasley (1983), Christofides & Beasley (1983), Van Roy (1986), Holmberg, Rönnqvist, &Yuan (1999), Wu, Zhang, & Zhang (2006)	Khumawala (1974), Jacobsen (1983), Domschke & Drexl (1985), Sridharan (1991, 1995), Agar & Salhi (1998), Rönnqvist, Tragantalerngsak, & Holt (1999), Ahuja, Orlin, Pallottino, Scaparra, & Scutellá (2004), Wu, Zhang, &Zhang (2006), Klose & Görtz (2006)	Delamaire, Fernández, & Ortega (1999) Diest et al (2006) Liao & Guo (2008)
	On a Line	Capacitated		Love (1976), Mirchandani, Kohli, & Tamir (1996), Brimberg & Mehrez (2001), Brimberg et al. (2001)	Eben-Chaime, Mehrez, & Markovic (2002)	

Future Investigations (2)



Future Investigations: A blend of

- *Location Routing Problems (see Nagy and Salhi, 2007)*
  - *A mixture of Location and Routing problems*
  - *the strategic and tactical planning of distribution management problems*
- *Inventory Location/ Routing Problems (see Moin, N. H., Salhi, S. and Aziz, N.A.B, 2010)*

THANK YOU

Very Much for Your Attention

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