IE 490 – Facility Location
Tentative Outline
Spring 2005

Week	Dates	Topic
1	3/29-30	Introduction and taxonomy of facility location models A simple analytic location model
2	4/4-6	Continuous location models Network location models
3	4/11-13	Discrete location models – Set covering, maximal covering, P-center, P-median, fixed charge and others
4	4/18-20	Solution of discrete location models – Lagrangian relaxation, dual ascent, construction and improvement heuristics, neighborhood search for P-median, genetic algorithms
5	4/25-27	Stochastic location models and partial covering location models
6	5/2-4	Location inventory models
7	5/9-11	Dynamic location models and multi-objective location
8	5/16-18	Hub location models
9	5/23-25	Competition in facility location models
10	6/1	Selected applications

Instructor

Mark S. Daskin
Department of Industrial Engineering and Management Sciences
Northwestern University
Evanston, IL 60208
Phone: 847-491-8796
FAX: 847-491-8005
e-mail: m-daskin@northwestern.edu

Office hours: M W 3-5 (or after class if we have make-up classes)

Note: If these hours do not work for a large percentage of the class, alternate times will be arranged. Also, if the posted office hours do not work for you for some reason, please do not hesitate to contact me by e-mail or phone to set up another mutually convenient time.

Evaluation and Assignments

The course will be graded based on three primary inputs:

Problem sets (some number)	60%
Student presentations of papers	25%
Class participation	15%

There will be about 3-5 homework assignments. Some are likely to involve some programming. These assignments will constitute 60% of the grade for each student. In addition, each student will be responsible for presenting 1-2 papers (depending on the enrollment). These presentations should be of an INFORMS presentation level at the beginning (20 minutes of overview of the problem and the key findings) followed, as needed, by a more detailed discussion of the particulars of the paper. Finally, students are expected to participate actively in class, particularly those classes in which other students are presenting material.

Tentative Schedule (to be discussed)

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
27-Mar	28-Mar	29-Mar First day of class (Monday schedule)	30-Mar Class	31-Mar	1-Apr	2-Apr
3-Apr	4-Apr Class	5-Apr	6-Apr Class	7-Apr	8-Apr	9-Apr
10-Apr	11-Apr Class	12-Apr	13-Apr Class	14-Apr	15-Apr	16-Apr
17-Apr	18-Apr **No class (INFORMS Palm Springs)**	19-Apr	20-Apr Class	21-Apr	22-Apr **Make-up class???**	23-Apr
24-Apr	25-Apr **No class (Passover)**	26-Apr	27-Apr Class	28-Apr	29-Apr **Make-up class???**	30-Apr
1-May	2-May Class	3-May	4-May Class	5-May	6-May	7-May
8-May	9-May Class	10-May	11-May Class	12-May	13-May	14-May
15-May	16-May Class	17-May	18-May Class	19-May	20-May	21-May
22-May	23-May Class	24-May	25-May Class	26-May	27-May **Make-up class???**	28-May
29-May	30-May No class (Memorial Day)	31-May	1-Jun **No class (MSD travels to Spain for ISOLDE X meeting)**	2-Jun	3-Jun	4-Jun

Readings

This section is divided into two parts. In the first part, I provide references to some recent and classic texts on location theory and modeling. Two that are of particular relevance to this course are those that are starred (*): Daskin (1995) and Drezner and Hamacher (2002).

The second part of the readings section below gives selected papers on each of the topics. We will be looking at **some** and certainly not all of these papers. Many are here for your reference only. The papers to be used in class will be posted on Blackboard or handed out in class. Some papers are designated with a (G) to indicate that they are a "golden oldie" or a classic in the field. Others are designated (O) to indicate that they are an "overview" paper. Within each group of papers, the papers are listed in chronological order.

Overall good references in location theory and modeling:

* Daskin, M. S., 1995. Network and Discrete Location: Models, Algorithms and Applications, John Wiley and Sons, Inc., New York.

Drezner, Z., (ed.), 1995, Facility Location: A Survey of Applications and Methods, Springer-Verlag, New York.

* Drezner, Z. and H. W. Hamacher (eds.), 2002, Facility Location: Applications and Theory, Springer, Berlin.

Francis, R. L., L. F. McGinnis, Jr., and J. A. White, 1992. Facility Layout and Location: An Analytical Approach, Prentice Hall, Englewood Cliffs, NJ.

Handler, G. Y. and P. B. Mirchandani, 1979. Location on Networks: Theory and Algorithms, MIT Press, Cambridge, MA.

Love, R. L., J. G. Morris, and G. O. Wesolowsky, 1988, Facilities Location: Models and Methods, North Holland, New York.

Mirchandani, P. B. and R. L. Francis, 1990. Discrete Location Theory, John Wiley, New York.

Sule, D., 2001, :Logistics and facility location and allocation, Marcel Dekker, New York

Week	Dates	Topic
1	3/29-30	Introduction and taxonomy of facility location models A simple analytic location model and the Weber problem

Daskin, M. S., 1995. Network and Discrete Location: Models, Algorithms and Applications, John Wiley and Sons, Inc., New York. **Chapter 1**

O Drezner, Z., K. Klamroth, A. Schobel, and G. O. Wesolowsky, 2002., "The Weber Problem," chapter 1 in Facility Location Theory: Applications and Methods, Z. Drezner and H. Hamacher eds., Springer-Verlag, Berlin, pp. 1-36.

2 4/4-6 Continuous location models
Network location models

G Goldman, A. J., 1971, "Optimal center location in simple networks," Transportation Science, **5**:2, pp. 212-221.

G Goldman, A. J., 1972, "Minimax location of a facility in a network," Transportation Science, **6**:4, pp. 407-418.

Drezner, Z. and A. J. Goldman, 1991, "On the set of optimal points for the Weber problem," Transportation Science, **25**:1, pp. 3-8.

3 4/11-13 Discrete location models – Set covering, maximal covering, P-center, P-median, fixed charge and others

G Hakimi, S., 1964, "Optimum Location of Switching Centers and the Absolute Centers and Medians of a Graph," Operations Research, **12**, pp. 450-459.

G Hakimi, S., 1965, "Optimum Location of Switching Centers in a Communications Network and Some Related Graph Theoretic Problems," Operations Research, **13**, pp. 462-475.

G Toregas, C., R. Swain, C. ReVelle and L. Bergman, 1971, "The Location of Emergency Service Facilities," Operations Research, **19**, pp. 1363-1373.

G Church, R. L. and C. ReVelle, 1974, "The Maximal Covering Location Problem," Papers of the Regional Science Association, **32**, pp. 101-118.

O Brandeau, M., and S. Chiu, 1989. "An overview of representative problems in location research," Management Science, **35**:6, 645-674.

O Daskin, M. S., L. V. Snyder and R. T. Berger, 2003, "Facility Location in Supply Chain Design," forthcoming in Logistics Systems: Design and Optimization, A. Langevin and D. Riopel editors, Kluwer.

4 4/18-20 Solution of discrete location models – Lagrangian relaxation, dual ascent, construction and improvement heuristics, neighborhood search for P-median, genetic algorithms

G Maranzana, F.E., 1964. On the location of supply points to minimize transport costs. Operations Research Quarterly, **15**, 261-270.

G Teitz, M. B. and P. Bart, 1968, "Heuristic Methods for Estimating the Generalized Vertex Median of a Weighted Graph," Operations Research, **16**, pp. 955-961.

G Erlenkotter, D., 1978. "A dual-based procedure for uncapacitated facility location," Operations Research, **26**:6, pp. 992-1009.

O Current, J., Daskin, M. and D. Schilling, 2002, "Discrete Network Location Models," chapter 3 in Facility Location Theory: Applications and Methods, Z. Drezner and H. Hamacher eds., Springer-Verlag, Berlin, pp. 81-118.

Fisher, M. L., 1985. "A applications oriented guide to Lagrangian relaxation," Interfaces, **15**:2, pp. 10-21.

Galvão, R. D., 1993. "The Use of Lagrangean Relaxation in the solution of uncapacitated facility location problems," Location Science, **1**, pp. 57-70.

Galvão, R. D. and C. ReVelle, 1996, "A Lagrangean Heuristic for the Maximal Covering Location Problem," European Journal of Operational Research, **88**, pp. 114-123.

Rolland, E., D. A. Schilling and J. R. Current, 1996, "An efficient tabu search procedure for the p-median problem," European Journal of Operational Research, **96**, 329-342.

Rosing, K. E. and C. S. ReVelle, 1997, "Heuristic concentration: two stage solution construction," European Journal of Operational Research, **97**, pp. 75-86.

Rosing, K. E., C. S. ReVelle, E. Rolland, D.A. Schilling, and J. R. Current, 1998, "Heuristic concentration and Tabu Search," *European Journal of* Operational Research, **104**, pp. 93-99.

Rosing, K. E., C. S. ReVelle, and D. A. Schilling, 1999, "A gamma heuristic for the p-median problem," European Journal of Operational Research, **117**, 522-532.

Bozkaya, B., J. Zhang and E. Erkut, 2002, "An efficient genetic algorithm for the p-median problem,"chapter 6, Facility Location: Applications and Theory, Z. Drezner and H. W. Hamacher, editors, Springer Verlag, Berlin.

5 4/25-27 Stochastic location models and partial covering location models

G Larson, R. C., 1974, "A hypercube queueing model to facility location and redistricting in urban emergency services," Computers and Operations Research, **1**, pp. 67-95.

Daskin, M. S., 1983, "A maximum expected covering location model: Formulation, properties, and heuristic solution," Transportation Science, **17**, 48-70.

Berman, O. and B. LeBlanc, 1984, "Location-relocation of mobile facilities on a stochastic network," **18**:4, 315-330

Berman, O., R. C. Larson and S. S. Chiu, 1985, "Optimal server location on a network operating as an M/G/1 queue," Operations Research, **33**, 746-771.

Current, J. R. and D. A. Schilling, 1989, "The covering salesman problem," Transportation Science, **23**:3, 208-213.

ReVelle, C. and K. Hogan, 1989, "The maximum availability location problem," Transportation Science, **23**:3, 192-200.

Daskin, M. S., S. M. Hesse, C. S. ReVelle, 1997, "α-Reliable P-Minimax Regret: A New Model for Strategic Facility Location Modeling," Location Science, **5**, 4, pp. 227-246.

Current, J.R., S. Ratick, and C.S. ReVelle,1998. "Dynamic Facility Location When the Total Number of Facilities is Uncertain: A Decision Analysis Approach," European Journal of Operational Research, **110**, pp. 597-609.

Averbakh, I. And O. Berman, 2000, "Minmax regret median location on a network under uncertainty," INFORMS Journal on Computing, **12**:2, 104-110.

Berman, O., Z. Drezner, and G. O. Wesolowsky, 2002, "Satisfying partial demand in facilities location," IIE Transactions, **34**, 971-978.

6 5/2-4 Location inventory models

G Baumol, W. J. and P. Wolfe, 1958, "A warehouse-location problem," Operations Research, **6**, 252-263.

G Eppen, G. D., 1979. "Effects of centralization on expected costs in a multi-location newsboy problem," Management Science, **25**:4, pp. 498-501.

Nozick, L. K. and M. A. Turnquist, 1998, "Integrating inventory impacts into a fixed-charge model for locating distribution centers," Transportation Research E, **34**:3, 173-186.

Erlebacher, S. J. and R. D. Meller, 2000, "The interaction of location and inventory in designing distribution systems," IIE Transactions, **32**, 155-166.

Teo, C. P., J. Ou and M. Goh, 2001, "Impact of inventory costs with consolidation of distribution centers," IIE Transactions, 99-110.

Nozick, L. K. and M. A. Turnquist, 2001, "A two-echelon inventory allocation and distribution center location analysis," Transportation Research E, **37**, 424-441.

Daskin, M. S., C. R. Coullard, and Z-J M. Shen, 2002, "An inventory-location model: formulation, solution algorithm and computational results," Annals of Operations Research, **110**, 83-106.

Shen, Z-J M., C. Coullard, and M. S. Daskin, 2003, "A Joint Location-Inventory Model," Transportation Science, **37**:1, 40-55.

Teo, C-P and J. Shu, 2003, "Warehouse-retailer network design problem," Operations Research, **52**:3, 396-408.

Lim, W-S, J. Ou and C-P Teo, 2003, "Inventory cot effects on consolidating weveral one-warehouse multiretailer systems," Operations Research, **51**:4, 668-672.

7 5/9-11 Dynamic location models and multi-objective location

Schilling, D. A., 1982. "Strategic facility location: the analysis of options," Decision Sciences, **13**, pp. 1-14.

Daskin, M. S., W. J. Hopp and B. Medina, 1992. "Forecast horizons and dynamic facility location planning," Annals of Operations Research, **40**, pp. 125-151.

Weber, C.A., and J.R. Current, 1993. "Multiobjective Analysis of Vendor Selection," European Journal of Operational Research, **68**, 173-184.

Current, J.R., and M. Marsh, 1993. "Multiobjective Transportation Network Design and Routing Problems: Taxonomy and Annotation," European Journal of Operational Research, **65**, 4-19.

Daskin, M. S., 1995. Network and Discrete Location: Models, Algorithms and Applications, John Wiley and Sons, Inc., New York. **Section 8.2.**

Serra, D. and V. Marianov, 1998. "The P-Median Problem in a Changing Network: The Case of Barcelona," Location Science, **6**, pp. 383-394.

Carrizosa, E. and D. Romero-Morales, 2001, "Combining minsum and minmax: A goal programming approach," Operations Research, **49**:1, 169-174.

Nozick, L. K. and M. A. Turnquist, 2001, "Inventory, transportation, service quality and the location of distribution centers," European Journal of Operational Research, **129**, 362-371.

Shen, Z-J M. and M. S. Daskin, 2003, "Tradeoffs Between Customer Service and Cost in an Integrated Supply Chain Design Framework," submitted to *Manufacturing and Service Operations Management*.

8 5/16-18 Hub location models

O'Kelly, M. O., 1986. "The location of interacting hub facilities," Transportation Science, **20**:2, pp. 92-106.

O'Kelly, M. E., 1987, "A Quadratic Integer Program for the Location of Interacting Hub Facilities," European Journal of Operational Research, **32**, pp. 393-404.

O'Kelly, M. E. and H. M. Miller, 1994, "The Hub Network Design Problems: A Review and Synthesis," The Journal of Transport Geography, **2**, pp. 31-40.

Campbell, J. F., 1994. "Integer programming formulations of discrete hub location problems," European Journal of Operational Research, **72**, pp. 387-405.

Skorin-Kapov, D. and J. Skorin-Kapov, Jadranka, 1994. "On tabu search for the location of interacting hub facilities," European Journal of Operational Research, **73**, pp. 502-509.

Lee, Y., B. H. Lim and J. S. Park, 1996. "A Hub Location Problem in Designing Digital Data Service Networks: Lagrangian Relaxation Approach," Location Science, **4**, pp. 185-194.

Ernst, A. T. and M. Krihnamoorthy, 1996, "Efficient Algorithms for the Uncapacitated Single Allocation *p*-Hub Median Problem," Location Science, **4**, pp. 139-154.

Pirkul, H. and D. A. Schilling, 1998. "An efficient procedure for designing single allocation hub and spoke systems," Management Science, **44**, 12, part 2, pp. S235-S242.

9 5/23-25 Competition in facility location models

Labbe, M. and S. L. Hakimi, 1991. "Market and locational equilibrium for two competitors," Operations Research, **39**:5, pp. 749-756.

Eiselt, H. A., G. Laporte and J.-F. Thisse, 1993. "Competitive location models: a framework and bibliography," Transportation Science, **27**, pp. 44-54.

Serra, D. and C. S. ReVelle, 1995, "Competitive location in discrete space," chapter 16 in Drezner, Z., (ed.), 1995, Facility Location: A Survey of Applications and Methods, Springer-Verlag, New York, pp. 367-386.

10 6/1 Selected Applications

TBA

NU Disability Policy

http://www.northwestern.edu/disability/policies/syllabus.html

To be eligible for disability-related services; students must have a visibly obvious or documented disability as defined by the Americans with Disabilities Act of 1990 (ADA) and Section 504 of the Rehabilitation Act of 1973. Under the ADA and Section 504, a person has a disability if he/she has a physical or mental impairment that substantially limits one or more major life activities such as walking, standing, seeing, speaking, hearing, sitting, breathing, and/or taking care of oneself.

SSD is the designated office at Northwestern University that obtains and files disability-related documents, certifies eligibility for services, determines reasonable accommodations, and develops plans for the provision of such accommodations. Students with disabilities are also offered auxiliary services, including assessment, library and lab assistants, notetakers, tutoring, assistive/adaptive technology, academic, psycho/social support, and mentorship.

Certifying Eligibility for Services

When appropriate, SSD requests disability-related documents from the appropriate licensed professional to certify a student as having a disability and to determine reasonable accommodations. Students who suspect that they have a disability, and have not received a formal assessment, may be referred to on-campus (Counseling and Psychological Services, Department of Communication Sciences and Disorders) or off-campus resources for an evaluation. Pending receipt of documentation, SSD reserves the right to deny services or accommodations.