LOC 351: Modeling Organizations

Winter 2007

Lecture: Tuesdays, 11:00 am – 1:30 pm; Annenberg Hall, Rm. G01
Lab: Thursdays, 11:00 am – 12:30 pm; Annenberg Hall, Rm. G01

Instructors:

Spiro Maroulis
Annenberg Hall, Rm. 224
Phone: (847) 491-3726
E-mail: s-maroulis@northwestern.edu

Rick Orlina
Annenberg Hall, Rm. 318
Phone: (847) 467-3871
E-mail: e-orlina@northwestern.edu

Course Description and Goals:

This course begins with the premise that we are all modelers in the sense that we construct explanations in our heads to simplify situations in which we want to answer a question. These may be personal questions, such as, "What major should I pursue?" or "Is this the right summer internship for me?" They also may be questions about organizations, such as, "Should we change the company's employee compensation policy?" When we observe organizations, gather information, draw inferences, and attempt to predict future outcomes, we are engaged in a process of informal modeling. This course will cover why and how you might convert such informal models and intuitions into more tangible, formal models you can 'run,' explore, or perhaps use to try to change some small corner of the world.

While there are many good reasons for creating formal models of social systems, this course places emphasis on one in particular: the process of modeling can help you improve your own mental models of how social systems work. To this end, the goals of the course are:

- to help you gain a greater understanding of the cause-and-effect relationships pertaining to organizational behavior and performance,
- to help you gain skill in using NetLogo, an agent-based modeling tool, and
- to increase your interest in modeling while getting you to think about how modeling may help you address problems that matter to you.

No prior modeling or programming knowledge is required.

Requirements:

1. Assigned Readings and Class Contribution — *20% of final grade*

Each week students will be expected to have read the assigned material and to actively participate in class discussions and in the weekly lab session. In addition, at least once during the quarter each student will prepare a brief review of an existing NetLogo model and present it to the class.

2. Assignments — *40% of final grade*

We believe that the best way to learn about complex systems and modeling is to build models. A series of homework assignments during the first half of the course will begin to develop your modeling skills. Students will often have an opportunity to work on these assignments during the weekly lab, but also should be prepared to spend additional time on the assignments outside of class.

All assignments must be posted on Blackboard no later than 8:00 AM on the due date specified in the syllabus. No credit will be given for assignments submitted after the deadline.

3. Final Project ***40% of final grade***

The central activity of the course is to investigate a social or organizational phenomenon of your choice through the creation of an agent-based model. The final deliverables will include (1) the NetLogo model used in your investigation, (2) a paper that describes your question, reasoning, and findings, and (3) a presentation on the final day of class. Homework assignments in the second half of the course are designed to give you an opportunity to work on these deliverables and get feedback from the instructors before the final version is due.

We will work with you to identify an appropriate project early in the quarter. Generally speaking, the key criteria for success on the project is demonstrating that you are able to use complex systems approach to shed light on a problem of interest. More specifically, we will expect all projects to:

- clearly identify a motivating question
- justify choices about the elements included and omitted from the model
- use the model to produce data that informs the motivating question
- discuss what the model implies vis-à-vis the motivating question

The models must include instructions on how to use them and what scenarios are interesting to run. The "information" tabs of the sample models in the NetLogo Models Library provide examples of what is expected. The papers must include a 2 page executive summary that outlines the rationale and findings of your work. The total length should not exceed 12 double-spaced pages. However, it is important to note that neither the length of the paper, nor the elegance of the model code will be important factors in our evaluation of the projects. We are predominately concerned with the content of your reasoning and analysis, and the clarity with which you communicate your ideas.

The final project is due by **8:00 AM on March 15**, and should be e-mailed to both instructors (model and paper).

4. Required Texts

- Course pack of weekly readings.
- Axelrod, R., & Cohen, M. D. (2000). *Harnessing complexity: Organizational implications of a scientific frontier*. New York: The Free Press.

5. Required Software

- Wilensky, U. (1999). *NetLogo*. http://ccl.northwestern.edu/netlogo/. Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston, IL.

Class Schedule, Weekly Readings, and Assignments

Class 1, January 5: *Introduction to complex systems and agent-based modeling*

The theoretical basis for this course comes from the emerging field of *complex systems* – a field that studies the dynamics of systems, such as organizations, whose behavior is the consequence of many different interdependent agents, and can be difficult to research using traditional analytical and empirical methods. To investigate the behavior of a natural or social system over time, complex systems research often makes use of computational *agent-based models*. In particular, agent-based models are used to discover the *emergence* of macro-level properties from the individual-level

actions of the agents, as well as identify *leverage points* in a social systems – points where a small, local change can have a disproportionate system-level impact.

In the first part of the course we will discuss why the ideas of emergence and leverage are so important in the study of organizations. We also will begin to build skill in NetLogo, a popular and easy to use agent-based modeling program.

Material to read for Class 1:

- Kelly, K. (1994). *Out of control: The new biology of machines, social systems, and the economic world*. Perseus Books. Chapters 1 & 2.
  In course pack but also available online at http://www.kk.org/outofcontrol/contents.php
- Bonabeau, E. (2002). Predicting the unpredictable. *Harvard Business Review*. 80(*3*), 109-116.

Assignment for the coming week:

- Download NetLogo and do Tutorials 1, 2, and 3 before the next class.

Class 2, January 9: *Modeling in NetLogo*

This class will be a hands-on session introducing how to model in NetLogo. Please make sure that you have completed NetLogo Tutorials 1, 2, and 3.

Material to read for Class 2:

- Rauch, J. (2002). Seeing around corners. *Atlantic Monthly*, 289(*4*), 35-48.
- **[Optional]** Gilbert, N., & Troitzsch, K. G. (2005). *Simulation for the social scientist*. Berkshire, England: Open University Press. Chapter 8, pp. 182-190.

Assignment for the coming week:

- HW #1: Introductory NetLogo Exercises.
  Due Friday, January 19, 8:00 AM.

Class 3, January 16: *Agents and their environment I: Natural selection*

One of the key issues that agent-based modeling brings to the forefront is the distinction between individual agency and environmental influence. In this class we turn our attention to models at one end of this spectrum, where individuals or organizations have little agency (at least in the short term) and the behavior of the system is driven primarily by environmental factors.

Material to read for Class 3:

- *Harnessing complexity*. Chapter 3.
- Handout on Sony Electronics display business to be distributed during lab
- Explore the Peppered Moths NetLogo model, using the suggestions on the information tab of the model as a guide (Models Library → Biology → Evolution → Peppered Moths)

Assignment for the coming week:

- HW #2: Extending a model.
  Due Friday, January 26, 8:00 AM.

Class 4, January 23: ***Agent variation and the trade-off between exploration and exploitation***

When building a complex systems model, one immediately confronts a host of questions about agents: What agents do I include? How do they decide what to do? On what dimensions do they differ? Can they be categorized into different types? How does a population of agents or strategies grow or shrink? While there are no easy answers to such questions, in this part of the course we begin to outline ways to think about the answers and the trade-offs involved. We pay particular attention to the importance of variation in populations of agents.

Material to read for Class 4:

- *Harnessing complexity*. Chapter 1 (all) & Chapter 2, pp. 33-50.
- March, J. G. (1991). Exploration and exploitation in organizational learning. *Organization Science*, *2*(1), 71-87.

Assignment for the coming week:

- HW #3: Creating a new model.
  Due Friday, February 2, 8:00 AM.

Class 5, January 30: ***The modeling process***

By this point in the course we would like you to start thinking seriously about a topic for your final project. To that end, together we will walk through each step of the modeling process, from identifying a problem to running computational experiments. While there is no recipe for modeling success, we will discuss different "architectures" of projects and practical tips for completing a successful model-based analysis of a problem.

Material to read for Class 5:

- TBA.

Assignment for the coming week:

- HW #4: Final project description.
  One-paragraph description of project idea due Friday, February 9, 8:00 AM.
  Complete description with model specs due Friday, February 16, 8:00 AM.

Class 6, February 6: ***Agents and their environment II: Networks***

An agent's environment does not comprise only the properties of its surrounding geographic locations – it also includes other agents. Indeed, one can view the pattern of relations between human agents as forming a social landscape that creates advantage for some, yet difficulty for others. In this class we discuss the theoretical basis for mechanisms that generate this type of "social capital", as well as introduce you to how one might use data on social networks to draw inferences about the impact of social structure on an agent. We also will discuss how the pattern of connections among agents can impact the overall behavior of a system.

Material to read for Class 6:

- Watts, D. J. (2003). *Six degrees: The science of a connected age.* New York: W. W. Norton & Company. Chapters 3 and 4.
- Burt, R. S. (2000). Structural holes versus network closure as social capital. In N. Lin, K. S. Cook, & R. S. Burt (Eds.), *Social capital: Theory and research*. (Note: only pp 1-9 of the copy of this chapter in your course pack are required reading for this week)

- Arthur, W. B. (1990). Positive feedbacks in the economy. *Scientific American*, 262(*2*), 92-97.
- **[Optional]** Coleman, J. S. (1988). Social capital in the creation of human capital. *The American Journal of Sociology*, 94, S95-S120.

Assignment for the coming week:

- Continue with HW#4.

Class 7, February 13: ***Presentation of Final Project Proposals***

Material to read for Class 8:

- *None*.

Assignment for the coming week:

- HW#5: First cut of model for final project.
  Due Friday, February 23, 8:00 AM.

Class 8, February 20: ***Agents and their behavior II: Interdependent decision-making***

Up to now our agents have been rather simple, in the sense that they only follow simple rules of behavior. In the next two classes we begin to make them more "intelligent." One approach that we take up in this class is to have agents behave "strategically." That is, when making decisions they not only react to their environment and each other's previously observed behavior, but they also take into account what they *expect* other agents to do. "Game theory" is the study of precisely this type of interdependent decision-making. In this class we introduce the basic ideas of game theory and show how agent-based modeling can be used to extend those ideas.

Material to read for Class 8:

- Brandenburger, A. M., & Nalebuff, B. J. (1995). The right game: Use game theory to shape strategy. *Harvard Business Review*, *73*(4), 57-71.
- Hofstadter, D. R. (1983). Metamagical themas: Computer tournaments of the prisoner's dilemma suggest how cooperation evolves. *Scientific American*, 248(*5*), 16-26.
- Schelling, T. (1984). *Choice and consequence*. Cambridge, MA: Harvard University Press. Chapter 10: What is Game Theory?

Assignment for the coming week:

- None. Work on project.

Class 9, February 27: ***Agents and their behavior III: Adaptive agents***

In the spirit of making our agents more "intelligent," there is no reason to assume that agents must adhere to a fixed set of predetermined rules. Indeed one of the characteristics of complex social systems is that the agents can learn new ways of succeeding in their environment. In the first half of this class, we will discuss several mechanisms, borrowed from the field of "evolutionary computation," through which agents can change and improve their rules over time. In the second half of this class, we will review the main ideas of the course, and revisit the question of what it means to say an organization "learns."

Material to read for Class 9:

- Gilbert, N., & Troitzsch, K. G. (2005). *Simulation for the social scientist*. Berkshire, England: Open University Press. Chapter 10, pp 217-218 and pp. 230-247.
- **[Optional]** Holland, J. (1995). *Hidden Order: How adaptation builds complexity*. Cambridge: Perseus books. Chapter 2.

Assignment for the coming week:

- None. Work on project.

Class 10, March 6 and / or March 8: ***Presentation of final projects***