Capturing Business Complexity with Agent-Based Modeling and Simulation: Useful, Usable, and Used Techniques

April 28, 2008

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1. Course Description

Course Title: Capturing Business Complexity with Agent-Based Modeling and Simulation: Useful, Usable, and Used Techniques

General Description: An intensive business applications-oriented introduction to agent-based modeling and simulation (ABMS) based on Michael North and Charles Macal's new book *Managing Business Complexity: Discovering Strategic Solutions with Agent-Based Modeling and Simulation* (Oxford 2007). The first half of the course will focus on ABMS concepts from the perspective of company managers and analysts. The second half of the course will focus on ABMS implementation from the perspective of company software developers and will include extensive hands-on exercises. Participants are invited to attend the first session, the second session, or both depending on their interests. Each participant will receive a copy of *Managing Business Complexity*, lunches, and break refreshments as part of their course fee.

Format and Topics: An intensive series of lectures and hands-on laboratories are used to introduce the foundational ideas and tools of ABMS and their application to business questions. Topics include the definition of agents, the design and construction of agents, the design and construction of agent environments, understanding of ABMS results, effective presentation of ABMS results, and applications of these core topics to specific examples. A Microsoft Excel retail store model, a Mathematica supply chain ABMS, and a Repast Simphony supply chain ABMS are discussed in detail. Registrants are asked to provide a paragraph on the ABMS applications they are most interested in to help focus instruction on the issues of greatest relevance to the audience.

Who Should Attend: Three groups should attend the course: managers involved in strategic planning or operations, analysts who design and operate models, and software developers who build models. The course introduces managers to ABMS, shows them how ABMS can be useful to their businesses, and describes how managers can present ABMS results to senior decision makers. Managers should attend the first session of the course. The course gives analysts the principles of ABMS design, discusses the fundamental features of the leading ABMS development tools and how these features affect ABMS design, and teaches them how to present ABMS results to decision makers. Analysts should attend both sessions of the course. The course gives software developers the basic principles of ABMS design and shows how to effectively use the leading ABMS development tools. Software developers should attend both sessions of the course.

Prerequisites and Requirements: There are no prerequisites for the first session. Prerequisites for the second session are a good knowledge of general ABMS concepts and a basic familiarity with programming in any high-level language or spreadsheet.

Course Dates: The course dates are Monday through Friday, May 12–16, 2008. Session I runs from Monday, May 12, 2008, through the morning of Wednesday, May 14, 2008. Session II runs from the afternoon of Wednesday, May 14, 2008, though Friday, May 16, 2008.

2. Course Schedule

2.1. Session I: ABMS Concepts

The course schedule for Session I will be as follows.

Day 1: Monday		
Start	**End**	**Section**
9:30 AM	9:45 AM	Welcome to the Course *Michael North, Argonne National Laboratory and The University of Chicago* An introduction to the course and the Santa Fe Institute Business Network.
9:45 AM	10:00 AM	Welcome to Argonne *Richard Cirillo, Argonne National Laboratory* A welcome to the course and Argonne National Laboratory.
10:00 AM	10:15 AM	Course Overview *Michael North, Argonne National Laboratory and The University of Chicago* ABMS is an exciting new approach to capturing business complexity. Developing the knowledge and skills necessary to apply ABMS to business questions requires focused learning. An overview of the focused learning approach offered by the course will be provided. The short-term goals of the course include imparting ABMS knowledge and skills that are useful in a business setting. The long-term goals of the course include building a vibrant business-oriented ABMS community.
10:15 AM	10:45 AM	ABMS Overview *Michael North, Argonne National Laboratory and The University of Chicago* This presentation provides an overview of ABMS and agents.
10:45 AM	11:15 AM	Break Refreshments will be served.
11:15 AM	Noon	The Roots of ABMS *Charles Macal, Argonne National Laboratory and The University of Chicago* This presentation introduces the history of agent-based modeling and simulation (ABMS) including John Conway's "Game of Life," Thomas Schelling's housing segregation model, and John Holland's seven features of complex adaptive systems. The presentation also discusses how ABMS is related to important neighboring fields of knowledge and technology such as multi-agent systems, management science, operations research, and network science.
Noon	1:30 PM	Lunch Work Session Lunch will be provided. During lunch participants will be asked to begin considering how ABMS might be applicable to their businesses.

1:30 PM	2:00 PM	ABMS Applications Discussion Session *Michael North, Argonne National Laboratory and The University of Chicago* Participants will discuss their questions about and thoughts on how ABMS might be applied to address issues of interest in their businesses.
2:00 PM	3: PM	The Role of ABMS *Charles Macal, Argonne National Laboratory and The University of Chicago* This presentation uses a supply chain example to compare and contrast agent-based modeling and simulation with other modeling techniques including systems dynamics, discrete-event simulation, participatory simulation, statistical modeling, risk analysis, and optimization. The presentation also discusses why businesses and government agencies do modeling and simulation.
3:30 PM	4:00 PM	Break Refreshments will be provided.
4:00 PM	5:00 PM	Discovering Agents and Agent Behaviors *Michael North, Argonne National Laboratory and The University of Chicago* This presentation details how to find, document, and conceptually implement agent behaviors in systems.

Day 2: Tuesday		
Start	**End**	**Section**
8:30 AM	10:00 AM	Office ABMS *Michael North, Argonne National Laboratory and The University of Chicago* This presentation provides an overview of ways to create agent-based models including agent-based modeling and simulation architectures and implementation tools. The presentation also discusses model growth paths for enhancing systems and related issues.
10:00 AM	10:30 AM	Break Refreshments will be provided.
10:30 AM	Noon	ABMS Verification and Validation *John Pepper, Santa Fe Institute* Verification approaches are used to determine how closely an implemented ABMS matches its intended design. Validation approaches are used to determine how well an ABMS reproduces the real situations being modeled. ABMS verification and validation will be discussed in detail.
Noon	1:30 PM	Lunch Work Session Lunch will be provided. During lunch participants will be asked to begin designing a conceptual ABMS architecture, agents, and an agent environment to address issues of interest in each of their businesses.

1:30 PM	2:00 PM	ABMS Applications Discussion Session *Charles Macal, Argonne National Laboratory and The University of Chicago* Participants will discuss the conceptual ABMS architectures, the agents, and the agent environments that they design to address issues of interest in each of their businesses.
2:00 PM	3:30 PM	A Visual Approach to Data Collection and Cleaning *Michael North, Argonne National Laboratory and The University of Chicago* The collection and management of data will be discussed. Approaches to cleaning data during and after collection will also be discussed.
3:30 PM	4:00 PM	Break Refreshments will be provided.
4:00 PM	5:00 PM	Understanding and Presenting ABMS Results *Charles Macal, Argonne National Laboratory and The University of Chicago* This presentation shows how to understand and present agent-based modeling and simulation results. A supply chain example is used to illustrate the concepts.

Day 3: Wednesday (Morning Sections)		
Start	**End**	**Section**
8:30 AM	9:30 AM	ABMS Example: Logistics and Supply Chain Model *Charles Van Groningen, Argonne National Laboratory* An example large-scale agent-based logistics and supply chain model will be discussed.
9:30 AM	10:30 AM	ABMS Examples: Energy Markets *Guenter Conzelmann, Argonne National Laboratory* Examples of agent-based energy market models will be discussed.
10:30 AM	11:00 AM	Break Refreshments will be provided.
11:00 AM	Noon	ABMS Examples: Banking/Finance and HIV Epidemics *David Sallach, Argonne National Laboratory and The University of Chicago* An example agent-based banking and finance model and an example HIV epidemic model will both be discussed.
Noon	1:30 PM	ABMS Example: Wildfire Evacuation Simulation *Stephen Guerin, RedfishGroup (Invited)* An example agent-based wildfire evacuation model will be discussed.

2.2. Session II: ABMS Software Development

The course schedule for Session II will be as follows.

Day 3: Wednesday (Afternoon Sections)		
Start	**End**	**Section**
1:30 PM	3:30 PM	Spreadsheet ABMS, Part I *Michael North, Argonne National Laboratory and The University of Chicago* Hands-on exercises will show how to create an agent-based model using a spreadsheet.
3:30 PM	4:00 PM	Break Refreshments will be provided.
4:00 PM	5:00 PM	Spreadsheet ABMS, Part II *Michael North, Argonne National Laboratory and The University of Chicago* Hands-on exercises will show how to create an agent-based model using a spreadsheet.
5:30 PM	8:30 PM	Optional Open Laboratory An optional opportunity to continuing working with the spreadsheet model will be provided. Instructors will be available to assist participants and answer their questions.

Day 4: Thursday		
Start	**End**	**Section**
8:30 AM	10:00 AM	A Supply Chain Example *Charles Macal, Argonne National Laboratory and The University of Chicago* Complex supply chain operation is a key feature of modern business. A supply chain example that will later be captured using ABMS will be introduced.
10:00 AM	10:30 AM	Break Refreshments will be provided.
10:30 AM	Noon	Capturing the Supply Chain Example with UML and Mathematica *Charles Macal, Argonne National Laboratory and The University of Chicago* A Mathematica ABMS approach to capturing the previously introduced supply chain example will be discussed using UML diagrams and Mathematica notebooks.
Noon	1:30 PM	Lunch Lunch will be provided.

1:30 PM	3:30 PM	Capturing the Supply Chain Example, Part I *Michael North, Argonne National Laboratory and The University of Chicago* *Additional Instructors from Argonne National Laboratory* Repast is a widely used free and open source cross-platform ABMS toolkit. A Repast ABMS approach to modeling the previously introduced supply chain example will be discussed. A hands-on approach will be used wherein the instructor will describe each ABMS concept and then the participants will immediately apply the concept to solidify their understanding.
3:30 PM	4:00 PM	Break Refreshments will be provided.
4:00 PM	5:00 PM	Capturing the Supply Chain Example, Part II *Michael North, Argonne National Laboratory and The University of Chicago* *Additional Instructors from Argonne National Laboratory* Hands-on "learning by doing" with the previously introduced supply chain model will continue.
5:30 PM	8:30 PM	Optional Open Laboratory An optional opportunity to continuing working with the model will be provided. Instructors will be available to assist participants and answer their questions.

Day 5: Friday		
Start	**End**	**Focus**
8:30 AM	9:00 AM	Introduction to SFI and the Business Network *Shannon Larsen, Santa Fe Institute* An introduction to both SFI and the SFI Business Network
9:00 AM	10:30 AM	Capturing the Supply Chain Example, Part III *Michael North, Argonne National Laboratory and The University of Chicago* *Additional Instructors, Argonne National Laboratory* Hands-on "learning by doing" with the previously introduced supply chain model will continue.
10:30 AM	11:00 AM	Break Refreshments will be provided.
11:00 AM	Noon	Extending the Supply Chain Example, Part I *Michael North, Argonne National Laboratory and The University of Chicago* *Additional Instructors from Argonne National Laboratory* Hands-on "learning by doing" with the previously introduced supply chain model will continue with a focus on extending the model using advanced methods.
Noon	1:30 PM	Lunch Lunch will be provided.

1:30 PM	3:00 PM	Extending the Supply Chain Example, Part II *Michael North, Argonne National Laboratory and The University of Chicago* *Additional Instructors from Argonne National Laboratory* Hands-on "learning by doing" with the previously introduced supply chain model will continue with a focus on extending the model using advanced methods.
3:00 PM	3:30 PM	Break Refreshments will be provided.
3:30 PM	4:30 PM	The Future of ABMS *David Sallach, Argonne National Laboratory and The University of Chicago* In recent times, a wide range of transdisciplinary techniques have coalesced into what is now known as ABMS. However, ABMS is still an embryonic and continuously evolving art and science. Areas of ABMS that are likely to change will be highlighted and exciting directions for future growth will be discussed.
4:30 PM	8:30 PM	Optional Open Laboratory An optional opportunity to continuing working with Repast will be provided. Instructors will be available to assist participants and answer their questions.

3. Course Instructors and Speakers' List

- Guenter Conzelmann, Argonne National Laboratory
- Richard Cirillo, Argonne National Laboratory
- Stephen Guerin, RedfishGroup *(Invited)*
- Shannon Larsen, Santa Fe Institute
- Charles Macal, Argonne National Laboratory and The University of Chicago
- John Pepper, Santa Fe Institute
- Michael North, Argonne National Laboratory and The University of Chicago
- David Sallach, Argonne National Laboratory and The University of Chicago
- Charles Van Groningen, Argonne National Laboratory

4. Course Fees

The course fees are shown below. Each participant will receive a copy of *Managing Business Complexity*, lunches, and break refreshments as part of their course fee. Reservations are on a first-come first-serve basis.

Table 1: Course Fees

Item	Total Fees for Business Development Network Members	Total Fees for Nonmembers
Session I	$399.00	$499.00
Session II	$399.00	$499.00
Both Sessions	$795.00	$995.00

The registration intent form (http://www.dis.anl.gov/conferences/abms/register.html) should be used to reserve a place in the course. Attendees will be contacted concerning payment arrangements following registration.