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Modeling Social Dynamics Workshop:  
*Sharing Perspectives across Disciplines\**

October 5-6, 2006  
National Science Foundation  
Arlington, Virginia

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## Agenda

*Pick-up badges in Stafford I*

*General workshop sessions in Stafford II room 525*

**Thursday, October 5, 2006**

07:30am-08:00am Pick up security badges (at Stafford I)  
08:00am-08:30am Refreshments  
08:30am-08:35am Welcoming Remarks: *Raima Larter*  
08:35am-08:45am Welcoming Remarks: *James Kitts*

### **SESSION 1: Theoretical Modeling of Social Dynamics**

08:45am-09:15am Plenary Speaker: *Yaneer Bar-Yam*  
09:15am-10:00am Breakout Sessions  
10:00am-10:15am Coffee Break  
10:15am-10:45am Plenary Speaker: *Peyton Young*  
10:45am-11:00am Participant Introductions  
11:00am-12:00pm Plenary Discussion

**12:00pm-1:15pm Lunch**

### **SESSION 2: Validating Models of Social Dynamics**

1:15pm-1:30pm Presider: *Robert Axtell*  
1:30pm-2:00pm Plenary Speaker: *Bernardo Huberman*  
2:00pm-2:30pm Plenary Speaker: *Peter Turchin*  
2:30pm-3:15pm Breakout Sessions  
3:15pm-3:45pm Plenary Discussion  
3:45pm-4:00pm Break

### **WRAP-UP: Recommendations for Promoting and Enhancing Modeling of Social Dynamics**

4:00pm-4:10pm Individual Brainstorming & Feedback  
4:10pm-4:30pm Small Group Brainstorming  
4:30pm-5:00pm Plenary Discussion

**6:00pm-7:30pm NSF Hosted “Networking Dinner” at Hotel**



## Agenda

### Friday, October 6, 2006

08:00am-08:20am Refreshments  
08:20am-08:30am Welcoming Remarks: *Tanzeem Choudhury*

### SESSION 3: Applications: Modeling the Dynamics of Networks

**Plenary Panel** Moderator: *Péter Érdi*  
08:30am-08:50am Speaker: *Noshir Contractor*  
08:50am-09:10am Speaker: *Gyorgy Korniss*  
09:10am-09:30am Speaker: *John Padgett*  
09:30am-09:45am Panel Discussion  
09:45am-10:00am Coffee Break  
10:00am-10:45am Breakout Sessions  
10:45am-11:00am Report on breakout sessions

### SESSION 4: Applications: Modeling Disasters

**Plenary Panel** Moderator: *Carter Butts*  
11:00am -11:20am Speaker: *Kathleen Carley*  
11:20am -11:40am Speaker: *Louise Comfort*  
11:40am -12:00pm Speaker: *Madhav Marathe*  
12:00pm -12:15pm Panel Discussion

### 12:15pm-1:15pm Lunch

1:15pm-2:00pm Breakout Sessions  
2:00pm-2:15pm Plenary Discussion

### WRAP-UP: Workshop Synthesis and Conclusion

2:15pm-2:30pm Small Group Discussion  
2:30pm-2:45pm Plenary Discussion  
2:45pm-3:00pm Workshop Evaluations

### 3:00pm Workshop Adjourned



## Session Descriptions

Thursday, October 5, 2006

### **SESSION 1 (8:45am-12:00pm)**

#### **Theoretical Models for Social Dynamics**

In this session, we will hold an interdisciplinary discussion on the promises and challenges of modeling social dynamics. Two plenary speakers – one from the physical sciences and one from the social sciences – will introduce our search for generic dynamic models that may share insights across disciplinary boundaries, or that may be applicable across a variety of theoretical problems.

**Plenary Speaker: Yaneer Bar-Yam, New England Complex Systems Institute**

*Modeling Complex Social Systems*

**Plenary Speaker: Peyton Young, Johns Hopkins University**

*Modeling Economic Complexity Using Methods from Statistical Mechanics*

#### **Breakout Sessions:**

These breakout sessions will consider the following two questions:

- \_\_\_\_\_ A. Describe some approaches to modeling the dynamics of non-social phenomena that you believe can be applied to modeling social dynamics. What are the biggest challenges?
- \_\_\_\_\_ B. Give examples of general theoretical frameworks or modeling approaches that you believe can apply to a great variety of social dynamics across multiple areas of study. Please discuss some strengths and potential obstacles of the approaches.



**Thursday, October 5, 2006**

**SESSION 2 (1:15pm-3:45pm)**  
**Validating Models of Social Dynamics**

Two plenary speakers and the session presider will discuss a variety of methods for validating theoretical models, including their goals, criteria for evaluating fit, and their interpretation and use of error.

**Session Presider: Robert Axtell, Brookings Institution/George Mason University**

**Plenary Speaker: Bernardo Huberman, Hewlett-Packard Labs**

*Thinking Globally and Acting Locally*

**Plenary Speaker: Peter Turchin, University of Connecticut**

*Testing Dynamic Models with Time-Series Data*

**Breakout Sessions:**

In these breakout sessions, we will discuss a variety of methods used to validate theoretical models. Four breakout groups will focus on the following approaches:

- \_\_\_\_\_ A. Showing that a model reproduces (“grows”) qualitative empirical patterns
- \_\_\_\_\_ B. Testing models by assessing fit to observed data; studying anomalies/outliers
- \_\_\_\_\_ C. Forecasting, predicting events and trends.
- \_\_\_\_\_ D. Aligning/“docking” a model with other models (non-empirical validation)

**WRAP-UP (4:00pm-5:00pm)**  
**Recommendations for Promoting and Enhancing Modeling Social Dynamics**

In this session, we are principally interested in encouraging fruitful interdisciplinary collaboration. We will discuss some specific ways that we may promote efficient and sustained diffusion of theoretical problems, models, and tools across disciplines. What are some specific ways that we may facilitate ongoing collaboration and intellectual ties among researchers across disciplines? What is the role of the National Science Foundation in pursuing these goals?



Friday, October 6, 2006

**SESSION 3 (8:30am-11:00am)**

**Applications: Modeling Dynamics of Networks**

Network models describe the transmission of disease among living organisms, the formation and dissolution of alliances between firms or political factions, the dynamics of fads, the spreading of email spam, or the pecking orders of chickens. Given that so many disciplines are addressing network models in some form, we use this intellectual lens as a case study.

The panel will discuss emerging general tools or frameworks that may provide insight into the dynamics of a great diversity of networks, along with some promising directions for future research.

**Session Moderator: Péter Érdi, Kalamazoo College**

**Plenary Speaker: Noshir Contractor, University of Illinois at Urbana-Champaign**

*From Disasters to WoW: Multi-theoretical Multilevel Modeling of Network Dynamics*

**Plenary Speaker: Gyorgy Korniss, Rensselaer Polytechnic Institute**

*Time Scales in Agreement Dynamics in Spatial and Random Complex Networks*

**Plenary Speaker: John Padgett, University of Chicago**

*Lessons for Contemporary Research from Renaissance Florence*

**Breakout Sessions:**

In these sessions, we will discuss some core principles that capture the dynamics of a variety of kinds of networks. Four breakout groups will focus on the following specific topics:

- \_\_\_\_\_ A. Networks and efficiency in diffusion
- \_\_\_\_\_ B. Robustness: Disrupting network flows
- \_\_\_\_\_ C. Evolution of networks
- \_\_\_\_\_ D. Networks spanning multiple levels (e.g. employees, firms, and industries)



**Friday, October 6, 2006**

**SESSION 4 (11:00am-12:15pm)**

**Applications: Modeling Disasters**

Disasters represent a particularly challenging class of substantive problems. For example, environmental disasters, terrorist attacks, sectarian feuds, and outbreaks of disease may all involve disruptions of multiple dynamic systems, leading to cascading failures and requiring coordinated responses among multiple agents who may themselves be debilitated or disconnected.

Three plenary speakers will discuss issues that we may face in understanding disasters, while describing empirical cases for our analysis.

***Session Moderator: Carter Butts, University of California, Irvine***

**Plenary Speaker: Kathleen Carley, Carnegie Mellon University**

*BioDefense - Using Modeling to Develop Mitigation Policies*

**Plenary Speaker: Louise Comfort, University of Pittsburgh**

*Modeling Rapidly Evolving Systems in Disaster Response*

**Plenary Speaker: Madhav Marathe, Virginia Tech**

*Interactions among Human Behavior, Social Networks, and Civil Infrastructures with Applications to Crises Planning and Response*

**Breakout Sessions**

In these breakout sessions, we will form interdisciplinary teams to discuss and analyze case studies. Each group will address a particular disaster event or class of disasters. What are some ways that research in dynamic modeling may help us understand and respond to these disasters?

**WRAP-UP (2:15pm-3:00pm)**

**Workshop Synthesis and Conclusion**



## Abstracts

### SESSION 1: Theoretical Models for Social Dynamics

**Yaneer Bar-Yam, New England Complex Systems Institute**

*Modeling Complex Social Systems*

Complex systems are systems that behave in ways that are not immediately inferable from the behaviors of their component parts. Clearly, many of the social systems we are interested in modeling fall into this category. From a complex systems perspective, social systems share many similarities with physical and biological systems, and the same set of tools and methods are useful in modeling all of them. Creating a useful model of any complex system requires identifying interdependencies between component parts, describing mechanisms of pattern formation, and developing a multiscale perspective – simultaneously considering behaviors at a broad range of spatial and temporal resolutions. This presentation will discuss general strategies for modeling complex systems and specific applications to social systems.

**Peyton Young, Johns Hopkins University**

*Modeling Economic Complexity Using Methods from Statistical Mechanics*

Standard models of economic and social processes often ignore the enormous complexity and dimensionality of such systems, on the grounds that they are impossible to analyze mathematically. We argue that this is not the case: methods from statistical mechanics and the theory of stochastic processes can be adapted to study the dynamic behavior of social and economic systems that have large numbers of interacting agents with different information, different preferences, and different rules of behavior. Standard methods for computing the asymptotic distribution of such systems are intractable due to their extremely high dimensionality, and simulations can give misleading results because of the enormous number of parameters that need to be specified. We outline an alternative approach based on the theory of large deviations, and show how it can be applied to concrete examples, including Thomas Schelling's celebrated model of residential segregation.

### SESSION 2: Validating Models of Social Dynamics

**Bernardo Huberman, Hewlett-Packard Labs**

*Thinking Globally and Acting Locally*

Understanding the relation between the local actions and the global behavior of large distributed systems is important to a number of domains. Examples are distributed knowledge, economic systems, social organizations and their dynamics. The overall dynamics of these systems is determined by the collective interactions of many autonomous principals operating in domains that often bridge several disciplines. It is well known that they display a repertoire of complex and useful behaviors, and thus it is important to understand them so that one can design new mechanisms for accessing the collective intelligence of social groups.



**Peter Turchin, University of Connecticut**

*Testing Dynamic Models with Time-Series Data*

Suppose that we have two or more alternative hypotheses (each translated into a mathematical model) purporting to explain the behavior of a certain dynamical system. If we have time-series data documenting fluctuations of key variables (variables that are suspected of being the drivers of the observed dynamics) than it is in general possible to determine which hypothesis/model does the best job accounting for the observed dynamics, by contrasting model predictions with data patterns. I will discuss approaches that have been developed for dealing with relatively short and noisy data sets that are typical for social and biological settings. The key idea is that of cross-validation---fitting models on a part of data (the fitting set) and then quantifying how well models predict the rest (the validation set). The approach will be illustrated with two case studies, the dynamics of religious conversion and linked oscillations of population numbers and sociopolitical instability.

**SESSION 3: Applications: Modeling Dynamics in Networks**

**Noshir Contractor, University of Illinois at Urbana-Champaign**

*From Disasters to WoW: Multi-theoretical Multilevel (MTML) Modeling of Network Dynamics*

This presentation describes a multi-theoretical multilevel (MTML) model to investigate the dynamics for creating, maintaining, dissolving, and reconstituting knowledge and social networks. Using examples from his research on emergency response networks, public health networks, and networks within communities playing WoW (the massively multi-player online role playing game, MMORPG), Contractor presents a framework to understand how modeling social and knowledge networks enable the growth of cyber-infrastructure and are in turn enabled by cyber-infrastructure.

**Gyorgy Korniss, Rensselaer Polytechnic Institute**

*Time Scales in Agreement Dynamics in Spatial and Random Complex Networks*

I will discuss the basic temporal (and spatial, where applicable) scaling properties of the "Naming Game", a recently proposed prototypical model for semiotic dynamics. The model can be motivated by the emergence of shared communication schemes in a population of autonomous (human or artificial) agents. Similar models capturing have also been employed to describe collaborative tagging. This phenomenon has been observed in popular web applications, where users spontaneously create loose categorization schemes ("folksonomy") to effectively organize and share large amount of information. The Naming Game provides a minimalist approach to describe the convergence process toward a shared "vocabulary". The talk will focus on the effect of the communication topology of the agents on the agreement process. Some of these effects are universal to a large class of models for opinion formation, where the system eventually reaches global consensus.

**John Padgett, University of Chicago**

*Lessons for Contemporary Research from Renaissance Florence*



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**SESSION 4: Applications: Modeling Disasters**

**Kathleen Carley, Carnegie Mellon University**

*BioDefense - Using Modeling to Develop Mitigation Policies*

Large scale biological and chemical disasters are rare events that nevertheless need to be planned for to mitigate the loss to human life and welfare. Multi-agent simulation models can play an important role in informing the policy debates around such planning and in training first responders by providing high fidelity examples of how such disasters might play out. This talk describes such a model - BioWar - and the issues associated with developing, validating and using such a model.

**Louise Comfort, University of Pittsburgh**

*Modeling Rapidly Evolving Systems in Disaster Response*

Rapidly evolving response systems following disaster represent a particular set of challenges to social and technical researchers. There are at least three sets of components involved, and each set is comprised of many subsets. The major sets include the physical infrastructure, engineered infrastructure, and the organizational infrastructure. Identifying the unique characteristics of this 'action arena' is the first task of analysis. Modeling the set of interactions within and among the technical and organizational components of the system offers a means to identify the rate and extent of change among the public, private, and nonprofit organizations involved in coordinated action. Working with researchers in the IISIS Lab, we have developed a preliminary model of dynamic assessment to track the information flow immediately before; during, and after extreme events. I will use the impact of Hurricane Katrina on the Gulf Coast to demonstrate a rapidly evolving system and the effects of pre-planning on actual performance in a disaster environment.

**Madhav Marathe, Virginia Tech**

*Interactions among human behavior, social networks, and civil infrastructures with applications to crises planning and response*

Human behavior, social networks, and the civil infrastructures are closely intertwined. Understanding the coupled evolution is critical for situational awareness and decision support for crises preparedness and response. For example, human behaviors and day to day activities of individuals create dense social interactions that are characteristic of modern urban societies. These dense social networks provide a perfect fabric for fast, uncontrolled disease propagation. Conversely, People's behavior in response to public policies and their perception of how the crises is unfolding as a result of disease outbreak can dramatically alter the normally stable social interactions. Effective planning and response strategies must take these complicated interactions into account. Computer Simulation aided decision support tools provide a practical approach for addressing such issues. The development of information-support environments for public health planning related to epidemics of infectious diseases provides a useful setting to illustrate and examine some of these issues. Agent based simulation of epidemics for the purpose of mitigation planning will be discussed in this context.



## Participant Information

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Rob Axtell has recently joined the faculty of the new Ph.D. Program in Computational Social Science at George Mason University. He is an Nonresident Senior Fellow at the Brookings Institution and an External Professor at the Santa Fe Institute. He holds an interdisciplinary Ph.D. from Carnegie Mellon University. His research involves the intersection of social science and computer science, through so-called agent-based computational models of social phenomena, in which populations of autonomous software agents—each agent representing an individual person—are instantiated. The agents then interact directly with one another according to simple rules of behavior, with patterns and structure emerging at the aggregate level. His book “Growing Artificial Societies: Social Science from the Bottom Up,” (MIT Press, 1996; with CD), co-authored with J. Epstein, was an early statement of the potential of multi-agent systems modeling in the social sciences. His research has appeared in academic journals (e.g., “Science,” “Proceedings of the National Academy of Sciences,” “Economic Journal,” “Computational and Mathematical Organization Theory”) as well as being reprised in the popular science press (e.g., “Scientific American,” “Science News,” “New Scientist,” “Discover,” “Technology Review”) and in newspapers and magazines (e.g., “Wall St. Journal,” “Los Angeles Times,” “Washington Post,” “Atlantic Monthly,” “New Yorker”). He has recently finished a new book entitled “Artificial Economies of Adaptive Agents: The Multi-Agent Systems Approach to Economics,” to be published in 2007.

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My research involves the application of formal (i.e., mathematical and computational) techniques to theoretical and methodological problems within the areas of social network analysis, mathematical sociology, quantitative methodology, and human judgment and decision making. Currently, my work focuses on: the structure of spatially embedded large-scale interpersonal networks; models for informant accuracy, network inference, and graph comparison; graphical representations of life history data; and models for human behavior in strategic situations. I am also interested in social phenomena related to crisis situations, and am involved in research which seeks to combine social science and information technology to improve crisis response.

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Kathleen M. Carley's research combines cognitive science, social networks and computer science to address complex social and organizational problems. Her specific research areas are dynamic network analysis, computational social and organization theory, adaptation and evolution, text mining, and the impact of telecommunication technologies and policy on communication, information diffusion, disease contagion and response within and among groups particularly in disaster or crisis situations. She and her lab have developed infrastructure tools for analyzing large scale dynamic networks and various multi-agent simulation systems. The infrastructure tools include ORA, a statistical toolkit for analyzing and visualizing multi-dimensional networks. ORA results are organized into reports that meet various needs such as the management report, the mental model report, and the intelligence report. Another tool is AutoMap, a text-mining system for extracting semantic networks from texts and then cross-classifying them using an organizational ontology into the underlying social, knowledge, resource and task networks. Her simulation models meld multi-agent technology with network dynamics and empirical data. Three of the large-scale multi-agent network models she and the CASOS group have developed in the counter-terrorism area are: BioWar a city-scale dynamic-network agent-based model for understanding the spread of disease and illness due to natural



epidemics, chemical spills, and weaponized biological attacks; DyNet a model of the change in covert networks, naturally and in response to attacks, under varying levels of information uncertainty; and RTE a model for examining state failure and the escalation of conflict at the city, state, nation, and international as changes occur within and among red, blue, and green forces. Dr. Carley is the director of the center for Computational Analysis of Social and Organizational Systems (CASOS) which has over 25 members, both students and research staff. She is the founding co-editor with Al. Wallace of the journal Computational Organization Theory and has co-edited several books in the computational organizations and dynamic network area.

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My research focuses on machine learning and machine sensing of human behavior and group dynamics. I am particularly interested in developing computational models that capture how humans interact with their environment and with each other and how the dynamics of these interactions evolve and change over time. I am currently involved in a project titled '*Creating Dynamic Social Network Models from Sensor Data*', where we are developing a hybrid method for rigorously observing and modeling structures of social interaction by collecting streaming sensor data (individual's physical location, speech, and motion) along with conventional survey measures.

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Louise K. Comfort has primary research interests in the field of decision making under conditions of uncertainty. She has worked in the field environment of rapid response to extreme events, such as earthquakes, hurricanes and the 2004 Sumatran Earthquake and Tsunami. She is engaged in research to model the interaction among changing conditions in the physical environment, the impact of these changes on the built and social environments, and the capacity of human organizations to assess this risk and respond in innovative, timely ways to reduce the consequences for human communities. Her current research ranges from collaboration with computer scientists in developing a model of early detection of tsunamis to a trial demonstration



project in modeling collaborative response to the risk of flooding among twenty-six communities in the Monongahela Valley in the Pittsburgh Metropolitan Region

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Noshir Contractor is a Professor in the Department of Speech Communication, Department of Psychology, Graduate School of Library and Information Science, and the Coordinated Science Laboratory at the University of Illinois at Urbana-Champaign. He is a Research Affiliate of the Beckman Institute for Advanced Science and Technology, Director of the Science of Networks in Communities (SONIC) Group at the National Center for Supercomputing Applications (NCSA) and Co-Director of the Age of Networks Initiative at the Center for Advanced Study at the University of Illinois at Urbana-Champaign.

He is investigating factors that lead to the formation, maintenance, and dissolution of dynamically linked social and knowledge networks in communities that include profit, non-profit, government as well as non-government agencies. Specifically, his research team is developing and testing theories and methods of network science to map, understand and enable more effective (i) disaster response networks, (ii) public health networks, (iii) transnational immigrant networks, (iv) massively multiplayer online role-playing game (MMORPG) networks and (v) environmental engineering networks. His research program has been funded continuously for the past decade by major grants from the U.S. National Science Foundation with additional funding from the U.S. National Institutes of Health (NIH), U.S. National Aeronautics and Space Administration (NASA), and the Rockefeller Foundation. Professor Contractor has published or presented over 250 research papers dealing with communication. His book titled 'Theories of Communication Networks (co-authored with Professor Peter Monge and published by Oxford University Press) received the 2003 Book of the Year award from the Organizational Communication Division of the National Communication Association. He is the lead developer of IKNOW (Inquiring Knowledge Networks On the Web), and its Cyberinfrastructure extension CI-KNOW, a network recommender system to enable communities using cyberinfrastructure, as well as Blanche, a software environment to simulate the dynamics of social networks.



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I have a general interest in applying the dynamical system theory to from the perspective of interacting qualities (molecules, neurons, species, ideas, innovations etc.) A recent topic is 'modeling innovation by a kinetic description of the patent citation system'.

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My research group is interested in behaviour modeling and activity recognition. Along that thread, one of the areas we are now concentrating on is modeling and analyzing group behaviors. At the meeting, I will be interested in discussions around how we can extend from analysis of behaviors from an individual, to a group, to a larger crowd. Our interests in these topics are from the low-level tracking and sensing of people to higher-level inference and discovery of interesting and sometime abnormal (or anomalous) activities.

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My research for the past five years has concentrated on characterizing collective intelligence and designing mechanisms for harvesting the implicit information that lies within social networks and organizations. While most people agree that a form of social mind can solve problems faster and better than individuals, it is often hard to organize a diverse network of people to do so in efficient fashion. Thus my effort at identifying communities of practice from email patterns and their access to common documents, and characterizing how information flows



through such communities. Last but not least we have developed and tested an incentive mechanism that can be used with small groups of people to predict the outcome of uncertain events.

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My research centers around inferring the behavior, plans, and intentions of people by combining sensor data and commonsense knowledge. A primary application of the work is to assistive technology for persons with cognitive disabilities, in the Assisted Cognition Project. I also participate in a University of Washington Human and Social Dynamics project that uses wearable sensors to infer human interactions. I am particularly interested in ways to learn and reason with models of human behavior that combine logic and probability.

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My research applies tools of formal demography and ecology to a broad range of social dynamics, including the births and deaths of organizations, flows of members entering, exiting, and migrating between organizations, and the diffusion of information and behavior in networks. I am particularly interested in modeling the co-evolution of behavioral norms and social networks in groups, including dynamics of convergence, factionalism, and polarization.

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My current research focuses on dynamics and collective behavior in many-particle or individual-based models. One line of my research focuses on the effects of network topology facilitating the interaction between individuals. Examples include synchronization phenomena in static and dynamic computer networks, optimization in large-scale communication and information networks, and agreement dynamics in sensor networks. Another line of studies focuses on invasion phenomena in spatially explicit individual-based models for ecological invasion, with applications to the spread of an advantageous allele or the introduction of invasive exotic species into a habitat.

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The new field of molecular anthropology has begun to offer fresh perspectives on human prehistory; one of its main foci is to dissect the historical processes that shape broad-scale human genetic patterns. This adds a realistic temporal dimension to our understanding of the social worlds that humans construct for themselves. But this added realism comes at a cost, as we move from simple equilibrium systems to non-equilibrium conditions. We have already outrun the mathematics of classical population genetics, which was developed to analyze equilibrium states. New models designed to make use of the torrent of new molecular data focus on out-of-equilibrium processes, bringing us closer to the finer scales at which most important social and demographic processes actually occur. We are using the last great Neolithic expansion of humans into pristine environments, the colonization of Indonesia and the Pacific, as a laboratory in which to investigate the evolution of social structure and language. The Austronesian expansion has been extensively studied by prehistorians, who use genetic and linguistic markers to reconstruct the history of colonization events. We are a little more ambitious: we wish to understand not only the history of colonization events, but their underlying causes. Using both forward- and backward-in-time simulations, we have begun to test hypotheses about the evolution of social structure and



language. For example, what are the effects of different types of kinship systems, or the adoption of irrigated agriculture, on population structure? And what are the respective consequences for relatedness networks of matrilineal or patrilineal descent; patriparallel or matrilineal marriage? How do networks evolve over time, and how are they affected by the physical environment? Our most interesting examples so far involve the development of water temple networks on the island of Bali.

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Prior to coming to NSF, my research involved the use of nonlinear dynamics to study chemical and physical processes in chemistry and biology which self-organize into temporal and/or spatial patterns. My group developed computational models for an enzyme-catalyzed oxidation known as the peroxidase-oxidase reaction that occurs in plants and exhibits a wide variety of interesting dynamical phenomena including bistability and both periodic and chaotic oscillations. Using the same sorts of theoretical and computational tools, we also developed models to explore the dynamical basis of the disease of epilepsy. Dynamical diseases are due to malfunctions in timing mechanisms rather than to specific anatomical or biochemical abnormalities. Examples include heart arrhythmias and certain neurological disorders including Parkinson's disease, as well as epilepsy. The models we developed for temporal lobe epilepsy consist of systems of differential equations that describe chemical kinetic and transport processes involving key molecular components such as glutamate (a neurotransmitter) and calcium ion (a signalling molecule involved in neuronal communication). These processes, when taken together, comprise a complex timing mechanism that may, when malfunctioning, lead to seizures.

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<http://people.cornell.edu/pages/mwm14/>

Why does our world not degenerate into the world of Mad Max? And why does it sometimes seem as if it may? Social order among interdependent agents can be imposed "from above" by a global policing mechanism or it can emerge "from below" through local interactions among adaptive agents with no centralized coordination. I assume no member of the population has the ability to identify or impose a global solution. But if everyone flies by the seat of their pants, how is social order possible? My current research explores the emergence of norms and



conventions in a self-organizing social system. The problem is one that defines the human condition: the overwhelming need for norms that constrain aggressive and mutually destructive behavior is no guarantee that such rules will emerge or be obeyed by anyone except a few "suckers." On the contrary, norms can even make matters worse, by obligating people to engage in behaviors that are individually and collectively harmful. It is not hard to explain why people comply with socially undesirable norms in the face of social pressure, but why would a skeptical population enforce these norms in the first place? My research team uses computational models and laboratory experiments with human subjects to look for elementary principles of interaction in social networks that may yield clues about possible answers.

Recent studies have focused on the importance of network cascades. We found that "small world" networks that are optimal for the spread of information and disease can inhibit the spread of risky or costly collective behaviors characterized by high thresholds of adoption. A new project funded by NSF uses data from the Internet Archive to track the spread of social contagions through on-line networks.

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My interests are in the area of the design of high-performance computational methods for the representation and analysis of large socio-technical and socio-economic systems.

Specific theoretical interests include: (i) formation, evolution, and dynamics of social, information, and infrastructure networks, (ii) co-evolution of social networks, individual behavior, and institutional policies, (iii) efficient, high-performance scalable algorithms and simulations for the analysis and modeling of socio-technical systems, and (iv) complexity science related to human and social dynamics.

The application of the theoretical ideas above to build practical computer based systems are involved. Examples of ongoing work over last ten years include: (i) a highly scalable service oriented information and modeling environment to support interaction based representation and analysis of biological, information, and social systems named Simfrastructure, (ii) an ongoing project funded by the NIH MIDAS program to develop agent based models to represent and analyze the spread of infectious diseases, (iii) the Urban Infrastructure Suite (UIS) of simulations for the Department of Homeland Security as a part of the National Infrastructure Simulation and Analysis Center (NISAC), and (iv) TRANSIMS, a microscopic end-to-end modeling tool used for transportation planning in large urban areas.

Each of these tools have been successfully used in a number of customer defined case studies and exercises related to infrastructure planning, protection, and criticality analysis. They demonstrate the integration of social, behavioral, and engineering methods using simulation-



based case studies to support decision making at the federal, state, and local levels; methods for assessing and mitigating vulnerabilities in large critical infrastructures; as well as successful modeling tools for analysis of socio-technical systems spanning very large urban areas. These practical socio-technical modeling tools solve real world problems that consist of approximately approx 10+ million individuals over large urban regions.

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Martina Morris is a professor of Sociology and Statistics at the University of Washington. She is the Director of the Center for Studies in Demography and Ecology, the Director of the Sociobehavioral and Prevention Research core of the UW Center for AIDS research (CFAR), and the co-director of the CFAR scientific program on Mathematical Modeling. Her current research focuses on modeling the spread of HIV through partnership networks. Together with colleague Mark Handcock (Statistics, UW), she leads a large NIH-funded interdisciplinary team of researchers at the University of Washington, the UW Network Modeling Project. The project seeks to integrate network survey design, data collection, statistical models, and dynamic simulations, to ensure a strong connection between theory, methods and data. The survey design and data collection issues are reviewed in her edited volume, *Network Epidemiology* (OUP, 2004). The statistical modeling and network simulation are based on exponential random graph models (ERGM), and the project has just released the first version of a statistical package, *statnet*, that implements these models (<http://csde.washington.edu/statnet/>). The package is written with an interface to the R statistical environment. It is based on an MCMC algorithm that is used for both parameter estimation and network simulation.

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For the past fifteen years, I have been constructing from primary archival sources a massive quantitative data set about social-network evolution over two hundred years, 1300-1500, in Renaissance Florence. This unprecedented data set contains information on about 50,000 persons: 10,000+ marriages, 14,000+ loans, 3,000+ business partnerships/firms, 40,000+ tax records, 12,000+ political-office elections, and so forth. Renaissance Florence was the arena for many history-altering organizational and technical inventions, in numerous domains. The project seeks to understand the genesis of many of these economic and political organizational inventions, primarily through tracing empirically and through modeling the catalytic co-evolution of multiple, cross-cutting social networks over time.

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Many historical processes are dynamic. Empires rise and fall, populations and economies boom and bust, world religions spread or wither. My current research interests focus on investigating such dynamical processes in history. Because nonlinear dynamical systems are capable of very complex behaviors, explicit mathematical models are a necessary ingredient in any research program for investigating them. We also need data describing how various aspects of the studied systems change with time. Fortunately, much quantitative empirical material on historical systems has been made available over the last couple of decades by workers in the field of cliometrics, and we can confidently expect that this process will continue in the future. The proposed general approach to investigating dynamical systems in history, therefore, is as follows. We start with verbal theories explaining historical change, either proposed by previous theorists, or formulated de novo. The verbal theories are translated into mathematical models, whose predictions can then be rigorously tested with cliometric data. This general approach is more fully developed in my 2003 book *Historical Dynamics*.

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Dynamics on/of networks, and particularly the reflection of network graph structure in the dynamic behavior. Monitoring, inference from limited/local measurements, identification, model reduction. Influence models as tractable representations of coupled stochastic automata. Applications in power systems, synchronization, cascading failure, epidemics, biological networks.

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My research is devoted to understanding how social and economic institutions evolve. For this purpose I have developed theoretical techniques for studying the asymptotic behavior very high-dimensional stochastic processes, which is how many economic and social phenomena must be represented. The theory has been applied to such diverse topics as residential sorting and segregation, the evolution of contractual norms, bargaining behavior, and the diffusion of innovations.



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