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IMA NEWSLETTER # 325

1–30 November 2003

2003–2004 Program

PROBABILITY AND STATISTICS IN COMPLEX SYSTEMS

See http://www.ima.umn.edu/complex/ for a full description of the 2003–2004 program on Probability and Statistics in Complex Systems: Genomics, Networks, and Financial Engineering

IMA schedules are subject to revision, particularly during workshops. See http://www.ima.umn.edu/~seminar/sched and http://www.ima.umn.edu/newsltrs/ for the latest scheduling information.

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PART I: NEWS AND NOTES

Board of Governors Meeting

The IMA Board of Governors had its annual meeting 10-11 October and unanimously approved the 2006-7 annual program "Applications of Algebraic Geometry".

The following individuals were elected to join the IMA Board of Governors, effective September 2004: Pamela Cook (University of Delaware), Katherine Ensor (Rice University), Robert Kohn (New York University) and Craig Poling (Lockheed Martin). Craig Poling will continue to serve on the IMA Industrial Advisory Board.

The following are the board members whose term is ending this year: Marsha Berger (Courant Institute), Jon Kettenring (Telcordia), Tom Kurtz (University of Wisconsin) and Bill Symes (Rice University). We thank them for their three years of service to the IMA.

PARTICIPATING INSTITUTIONS: Centrum voor Wiskunde en Informatica (CWI), Consiglio Nazionale delle Ricerche, Georgia Institute of Technology, Indiana University, Iowa State University, Kent State University, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, Michigan State University, Mississippi State University, Northern Illinois University, Ohio State University, Pennsylvania State University, Purdue University, Rice University, Sandia National Laboratories, Seoul National University (BK21 Math-SNU), Seoul National University (SRCCS), Texas A&M University, University of Chicago, University of Cincinnati, University of Delaware, University of Houston, University of Illinois (Urbana), University of Iowa, University of Kentucky, University of Maryland, University of Michigan, University of Minnesota, University of Notre Dame, University of Pittsburgh, University of Wisconsin, University of Wyoming, Wayne State University.

PARTICIPATING CORPORATIONS: Boeing, ExxonMobil, Ford, General Motors, Honeywell, IBM, Lockheed Martin, Lucent, Motorola, Schlumberger, Siemens, Telcordia Technologies, 3M.

Version of December 4, 2003

IMA "Hot Topics" Workshop:

Agent Based Modeling and Simulation

3-6 November 2003
Organizers: Filippo Castiglione (CNR, Italy), Jane K. Cullum (Los Alamos National Laboratory), Stephen Eubank (Los Alamos National Laboratory), Jeffrey O. Kephart (Thomas J. Watson Research Center), Madhav V. Marathe (Los Alamos National Laboratory), Zoltán Toroczkai (Los Alamos National Laboratory),

See http://www.ima.umn.edu/complex/fall/agent.html

IMA Workshop:

Networks and the Population Dynamics of Disease Transmission

17-21 November 2003
Organizers: Martina Morris (University of Washington), Claudia Neuhauser (University of Minnesota),

See http://www.ima.umn.edu/complex/fall/c3.html

IMA Website

Comments or suggestions concerning the IMA website may be addressed to

`webmaster@ima.umn.edu`.

In particular, we appreciate any information about World-Wide Web links appropriate to current and upcoming IMA programs.

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PART II: Schedule for 1–30 NOVEMBER 2003

Monday, November 3

IMA "Hot Topics" Workshop:

Agent Based Modeling and Simulation

3-6 November 2003

Organizers: Filippo Castiglione (CNR, Italy), Jane K. Cullum (Los Alamos National Laboratory), Stephen Eubank (Los Alamos National Laboratory), Jeffrey O. Kephart (Thomas J. Watson Research Center), Madhav V. Marathe (Los Alamos National Laboratory), Zoltán Toroczkai (Los Alamos National Laboratory),

See http://www.ima.umn.edu/complex/fall/agent.html

Agent based modeling and simulation, an approach to simulating the behavior of a complex system in which agents interact with each other and with their environment using simple local rules, is gaining popularity and widespread use in many areas. Successes of this approach in predicting traffic flow in metropolitan areas, the spread of infectious diseases, and the behavior of economic systems have generated further interest in this powerful technology.

This workshop will bring together leading researchers in diverse areas wherein agent based modeling has proliferated with the goal of identifying fundamental scientific questions whose answers could form the basis of a sound mathematical and computational theory for agent based modeling and simulation.

The foundational issues pertaining to agent based modeling and simulation (ABMS) are unique. In addition, the application areas where such approaches are being employed are very diverse, ranging from software systems at one of the end of the spectrum to information economies and critical infrastructures at the other end. Hence, building a sound and widely applicable theory for such systems will require an inter-disciplinary approach and the development of new mathematical and computational concepts. The proposed workshop will be a step in this direction.

The workshop will consist of presentations by invited speakers as well as working group sessions. The workshop program will be organized so that there is ample time for discussions in order to foster active interaction between attendees in an effort to achieve the above stated objectives. A proceedings based on the contents of the workshop will be produced. It is hoped that the collection of research articles will provide a road map for future development.

All talks are in Lecture Hall EE/CS 3-180 unless otherwise noted.

8:30–9:00	**Registration (with coffee and light refreshments)**	Reception Room EE/CS 3-176
9:00–9:10	**Douglas N. Arnold, Scot Adams, and Organizers**	Welcome and Introduction
9:10–9:30	**Road Map**	The Organizers

SESSION 1: CRITICAL INFRASTRUCTURE

9:30–10:05	**Christopher L. Barrett** Los Alamos National Laboratory	A Theoretical and Applied Program in Simulation Science and Interaction Based Computing

Abstract: Computer simulation can be viewed as a computational approach for explicit calculation of local interactions among system piece parts, resulting in a dynamical representation of an overall system composed of those parts. We will describe a theoretical program and the associated applied program of research that has been developed by following and elaborating this truism.

Formally we begin with a set of local maps, a dependency structure among them and an order of evaluation of those maps that is consistent with the dependency structure. We call such systems Sequential Dynamical Systems, (SDS). In discrete event simulations, these essential elements correspond to agent/objects, their interaction protocols and constraints, and an update schedule. Thus the algebraic, or structural, properties of SDS form an axiomatic foundation for computer simulation. Some of these properties will be described.

While the algebraic treatment of SDS for the most part ignores the details of actual evaluation of the local mapping, when a procedural interpretation of the local maps is introduced, a natural algorithmic perspective to SDS, called Computational SDS, (cSDS) arises. Examples of some complexity bounds on cSDS and their implicit algorithmic interpretations, normal forms, and other such issues will be discussed. One question we address in this regard is, "are simulations merely optional?" Another is, "are simulations computationally limited?"

The application of these conceptual tools to very large socio-technical systems forms the foundation of the Los Alamos approach to our scientific and technical role in the National Infrastructure Simulation and Analysis Center (NISAC), a new national capability established in the Patriot Act of October 2001. A program to produce highly advanced and interoperable transportation-, mobile population-, mobile computation-, commodity markets- and epidemiological simulation technology will be overviewed and related to the theoretical program.

10:05–10:40	**K. Mani Chandy** California Institute of Technology (CALTECH)	Sense and Respond Systems for Crisis Management

Abstract: Managing crises — such as terrorist attacks, hurricanes, and pandemics — and other fast-moving situations, requires sense and respond platforms that can be configured to sense complex conditions in the extended environment and respond appropriately. This talk discusses distributed technologies and design methodologies for configuring sense and respond systems as a crisis unfolds.

10:45–10:55	**Break**	Reception Room EE/CS 3-176

SESSION 2: ECONOMICS AND MARKETS

11:00–11:35	**Leigh Tesfatsion and Deddy Koesrindartoto** Iowa State University	Testing the Reliability of FERC's Wholesale Power Market Platform: An Agent-Based Computational Economics Approach

Abstract: Given the serious reliability problems that have recently arisen in the restructured electricity markets in California and the Northeast, policymakers are now calling for more comprehensive testing of market restructuring proposals prior to implementation. The objective of our collaborative project with the Los Alamos National Laboratory is to test the reliability of the Wholesale Power Market Platform (WPMP), a standard market design proposed in April 2003 by the Federal Energy Regulatory Commission for U.S. wholesale electricity markets. The WPMP design has been adopted or submitted for adoption by wholesale electricity market operators in New England, New York, the mid-Atlantic states, California, and the Midwest.

The WPMP design is extremely complex and recent in origin, rendering difficult the application of traditional analytical and statistical tools. We are therefore taking a different approach, the development of an agent-based computational economics (ACE) framework incorporating the key features of the WPMP design. This ACE electricity framework will be used to test the extent to which the WPMP design results in efficient, fair, and orderly market operations over time, despite attempts by market participants to gain advantage through strategic pricing, capacity withholding, and induced transmission grid congestion. This is a challenging issue of utmost importance for social welfare and national security. Our presentation will

report on our progress to date.

11:35–12:10	**Jeffrey O. Kephart** IBM Thomas J. Watson Research Center	Software Agents and the Information Economy

Abstract: Humans are on the verge of losing their status as the sole economic species on the planet. In private laboratories and in the Internet laboratory, researchers and developers are creating a variety of autonomous, economically-motivated software agents endowed with algorithms for maximizing profit or utility. Many economic software agents will function as miniature businesses, purchasing information inputs from other agents, combining and refining them into information goods and services, and selling them to humans or other agents. Their mutual interactions will form the information economy: a complex economic web of information goods and services that will adapt to the ever-changing needs of people and agents. The information economy will be the largest multi-agent system ever conceived, and an integral part of the world's economy.

One cannot predict how this new world economy will behave simply by extrapolating from hundreds of years of economies in which humans have been the only players. Economic software agents differ from their human counterparts in several ways. They operate more quickly on more up-to-date and accurate information, yet on the other hand they have much less world experience and common sense. In an effort to both understand and design the macroeconomic behavior of the future information economy, we have simulated several different markets and economies populated with economic software agents employing a variety of plausible pricing and bidding algorithms. I will present several interesting macroeconomic behaviors that we have observed and analyzed, including cyclical price wars and complex strategic interactions that are reminiscent of the prisoner's dilemma. I will then discuss how insights gained from our studies can be used to design not just market mechanisms, but the agents themselves – an opportunity that traditionally has not been available to economists.

12:10–1:35	**Lunch with talk by John Lavery** Army Research Office, Army Research Laboratory	Agent-Based Systems: Mathematical Models and Army Needs

Abstract: Classical physics-based models for agent-based systems have been proposed. A preferable approach is to start by defining the internal dynamics of agent-based systems and to create the models based on these dynamics. Whatever the source of the models, they should eventually be justified on the basis of the internal dynamics of agent-based systems. Agent-based systems are needed for sensorwebs, information mining, multi-robot swarming and many other Army/DoD applications.

SESSION 3: PHYSICS

1:35–2:10	**Massoud Amin** University of Minnesota	Toward Self-healing Electricity Infrastructure

Abstract: With the tragic events of 9/11 permanently etched in our minds, the recent massive power outages brought eerie reminders of the events that shook our world two years ago. While we were relieved that there was no apparent evidence of terrorism, the cascading blackouts are not merely a warning, but the sudden and stark reality of the vulnerable condition of our electricity infrastructure becoming visible.

Electricity infrastructure touches us all – therefore the key question is whether we are prepared for the future storms; more pertinent to this workshop, the key challenge is the control of a heterogeneous, widely dispersed, yet globally interconnected system is a serious technological problem in any case. It is even more complex and difficult to control it for optimal efficiency and maximum benefit to the ultimate consumers while still allowing all its business components to compete fairly and freely.

By way of background, the North American power network represents an enormous investment - this infrastructure includes over 15,000 generators in 10,000 power plants, along with hundreds of thousands of miles of transmission lines, and distribution networks; it is estimated to be worth over $800 billion. The transmission and distribution plant-in-service was valued at $358 billion in 2000. With its millions of relays, controls and other components, it is the most complex machine ever invented. The National Academy of Engineering has hailed the North American power delivery system as the supreme engineering achievement of the 20th century because of its ingenious engineering, catalytic role for other technologies and impact in improving quality of life down to the household level.

Through this network, every user, producer, distributor and broker of electricity buys and sells, competes and cooperates in an "Electric Enterprise." Every industry, every business, every store and every home is a participant, active or passive, in this continent-scale conglomerate. Over the next few years, the Electric Enterprise will undergo dramatic transformation as its key participants – the traditional electric utilities – respond to deregulation, competition, tightening environmental/land-use restrictions, and other global trends.

¿From a strategic R & D viewpoint, agility and robustness/survivability of large-scale dynamic networks that face new and unanticipated operating conditions will be presented. A major challenge is posed by the lack of a unified mathematical framework with robust tools for modeling, simulation, control and optimization of time-critical operations in complex multicomponent and multiscaled networks.

In this presentation, I'll present a model and simulation of the "Electric Enterprise" (taken in the broadest possible sense) that has been developed. The model uses autonomous, adaptive agents to represent both the possible industrial components, and the corporate entities that own these components and are now engaged in free competition. The goal in building this tool is to help these corporations evolve new business strategies for internal reorganization, external partnerships and market penetration.

This presentation will also focus on a strategic vision extending to a decade, or longer, that would enable more secure and robust systems operation, security monitoring and efficient energy markets.

2:10–2:45	**Akira Namatame** National Defense Academy	The Design of Desired Collectives with Agent-based Simulation

Abstract: Collective means any pair of a complex system of autonomous agents, together with a performance criterion by which we rank the behavior of the overall system. In examining collective, we shall draw heavily on the individual behavior. It might be argued that understanding how individuals behave is sufficient to describe collectives. In this presentation, I will take a different view. Although individual behavior is nested within important to understand, it is not sufficient to analyze emergent behaviors of collectives. These situations, in which an agent decision depends on the decisions of the others, are the ones that usually do not permit any simple summation or extrapolation to the aggregates. To make that connection we have to look at the micro-macro loop between agents and the collectivity. There is no presumption that a collection of interacting agents leads to collectively satisfactory results without any central authority. The system performance of interacting agents crucially depends on the type of interactions among agents as well as how they adapt to others. There are two closely related issues concerning collective, (1) the forward problem of how the fine-grained structure of the system underlying a collective determines its complex emergent behavior and therefore its performance, and (2) the inverse problem of how to design the structure of the system underlying a collective to induce optimal performance. I will discuss how agent based simulation contributes to answer these issues.

2:45–3:20	**Peter F. Stadler** Universität Leipzig, Germany	The Structure of Fitness Landscapes

Abstract: Fitness Landscapes arise as a unifying concept in evolutionary biology, the statstics of disordered systems, and evolutionary computation. A variety of different approaches can be used to quantify global geometric features of landscapes, among the measures of correlation, the distribution of metastable states, and the collection of energy barriers.

3:25–3:35	**Break**	Reception Room EE/CS 3-176

SESSION 4: MATH AND COMPUTER SCIENCE

3:40–4:15	**Gabriel Istrate** Los Alamos National Laboratory	Adversarial Scheduling Models for Game Theoretic Dynamics

Abstract: Game-theoretic equilibria are steady-state properties; that is, given that all the players' actions correspond to an equilibrium point, it would be irrational for any of them to deviate from this behavior, given that the others stick to their strategy. A major weakness of this type of concept is that it fails to predict how players arrive at this equilibrium in the first place, or how they "choose" one such equilibrium, if several such points exist. One way to justify the emergence of such equilibria is provided by the theory of learning in games, which regards them as the result of an evolutive"learning"

process. Such models assume one (or several) populations of agents that interact by playing a certain game, and updating their behavior based on the outcome of this interaction.

In order for evolutionary results of this sort to offer convincing insights on equilibrium selection in real-life situations, they have to display "robustness" with respect to the various idealizations inherent in the mathematical model. One such idealization is random scheduling: agents that are given the chance to update are chosen according to a scheme that involves random choice. However, "real" social interaction is not random, and it is not clear whether the randomness assumption is essential for the validity of these results.

In this talk (based on results obtained in collaboration with M.V. Marathe and S.S. Ravi) we explicitly advocate a reexamination of the conclusions of the theory of learning in games under adversarial scheduling models, and present a couple of examples from the game-theoretic literature (e.g. Peyton Young stochastically stable equilibria, the "colearning" model due to Shoham and Tennenholtz, etc) that show that such an analysis is feasible (and interesting).

4:15–4:30	**Group Photo**	
4:30–6:00	**IMA Tea and more (with Informal Poster Session)**	IMA East, 400 Lind Hall
poster session	**David Francis Batten** CSIRO, Australia	CSIRO's Agent-Based Modelling Working Group

Abstract: Australia's largest research organization, CSIRO (Commonwealth Scientific and Industrial Research Organization) established a Centre for Complex Systems Science (CSS) two years ago. Within this CSS Centre, there is a small suite of agent-based modelling projects embracing a broad range of contexts – from electricity markets to fishing behaviour, rangelands and river catchments. The CSIRO Agent-based Modelling Working Group nurtures each of these projects by facilitating interaction tasks such as regular workshops and working group meetings. International experts from Europe and North America also attend. The Coordinator of this Working Group, Dr. David Batten (David.Batten@csiro.au) is directing the ABM work on Australia's electricity market, but he would be pleased to discuss any of the Working Group's ABM projects with interested parties. Collaboration with research groups engaged in similar research in other countries would be especially welcome.

poster session	**Stephen Eubank** Los Alamos National Laboratory	Urban Infrastructure Suite: An integrated Simulation Based Analytical Tool for Critical Infrastructures
poster session	**Maria Gini** University of Minnesota	Scheduling Tasks with Precedence Constraints to Solicit Desirable Bid Combinations

Abstract: Joint work with Wolfgang Ketter and John Collins, Dept of Computer Science and Engineering, University of Minnesota.

We study the problem of optimizing the time windows in Requests for Quotes that an agent sends to other agents to obtain bids for combinations of tasks with complex time constraints and interdependencies. Our approach uses Expected Utility Theory to reduce the likelihood of receiving unattractive bids, while maximizing the number of bids that are likely to be included in the winning bundle. We describe the model, illustrate its operation and properties, and discuss what assumptions are required for its successful integration into multi-agent applications.

poster session	**Tad Hogg** HP Labs	Simulating Nanorobots in Viscous Fluids

Abstract: Developing nanoscale robots (nanorobots) presents difficult fabrication and control challenges [4]. Of particular interest are medical applications [2] in which the robots operate in fluid microenvironments in the body. While such robots cannot yet be fabricated, theoretical and simulation studies identify plausible designs and capabilities [1,2].

To aid investigation of system-level control algorithms for these robots, we present a physically-based simulator for nanorobots in a simplified fluid environment motivated by medically relevant microenvironments. The robots' motions,

characterized by a low Reynolds number, are quite different from common experience with larger, faster flows [3].

[1] K. E. Drexler, Nanosystems, Wiley 1992

[2] R. A. Freitas Jr., Nanomedicine, vol. 1, Landes Bioscience, 1999, at www.nanomedicine.com

[3] E. M. Purcell, "Life at Low Reynolds Number", American Journal of Physics, 45:3-11 (1977)

[4] A. A. G. Requicha, "Nanorobots, NEMS and Nanoassembly", to appear in Proc. of IEEE special issue on Nanoelectronics and Nanoprocessing

Joint work with Adriano Cavalcanti.

poster session	**Wolfang Ketter** Universtity of Minnesota	An Evolutionary Framework for Studying Behaviors of Economic Agents

Abstract: We propose an evolutionary approach for studying strategic agents that interact in electronic marketplaces. We describe how this approach can be used when agents' strategies are based on different methodologies, employing incompatible rules for collecting information and for reproduction. We present experimental results from a simulated market, where multiple service providers compete for customers using different deployment and pricing schemes. The results show that heterogeneous strategies evolve in the same market and provide useful research data.

poster session	**Adam Landsberg** Claremont McKenna, Pitzer and Scripps Colleges	The Emergence of Temporal Correlations in a Study of Global Economic Interdependence

Abstract: We develop a simple firm-based automaton model for global economic interdependence of countries using modern notions of self-organized criticality and dynamical renormalization group methods. We demonstrate how extremely strong statistical correlations can naturally develop between two countries even if the financial interconnections between those countries remain very weak. Potential policy implications of this result are also discussed.

Joint work with Eric J. Friedman (Cornell University) and Simon Johnson (MIT)

poster session	**Reinhard Laubenbacher** Virginia Bioinformatics Institute at Virginia Tech	A Computational Algebra Algorithm for Reverse-engineering of Gene Regulatory Networks

Abstract: One of the central problems in systems biology is to model gene regulatory networks from experimental data. Several modeling frameworks have been proposed, that can be categorized broadly into static versus dynamic, continuous versus discrete, and deterministic versus stochastic. We present a method that infers a multi-state, discrete dynamic network from one or more time series of DNA microarray measurements. The method utilizes algorithms from computational algebra and algebraic geometry. We validate our reverse-engineering algorithm using simulated data generated by a Boolean network model of the regulatory network responsible for pattern formation in Drosophila melanogaster.

poster session	**Kristian Lindgren** Chalmers/Göteborg University	Cooperation in an Unpredictable Environment

Abstract: One of the main limitations with the Prisoner's Dilemma game and many of the similar games studied is the static character of the interaction situation, i.e that players always have the same payoff elements in all encounters. In practice it is much more common that circumstances change over time, so that the payoff elements are rarely the same at any two encounters.

We investigate the evolution of cooperation in a random environment, when players engage in repeated interactions. Strategies are represented as a small set of behavioral states, with transitions between them.

For very low mistakes rates, the level of cooperation is high but unstable. A qualitative model is introduced to show that the fluctuations are due the breakdown of reciprocation at high levels of cooperation. At higher mistakes rates, the genetic drift is decreased significantly.

We conclude that also with players with very limited faculties, it is possible to establish robust cooperation in the presence of uncertain future payoffs. The possibility of making mistakes makes it harder to establish robust cooperation, but on the other hand it is not as susceptible to genetic drift.

Joint work with Anders Eriksson.

poster session	**Kristian Lindgren** Chalmers/Göteborg University	A Scale-Free Network Model of Urban Economics

Abstract: The geographic distribution of human land use exhibits a wide range of large-scale regularities with maybe the most widely known example being the rank-size rule, also known as Zipf's Law. This rule states that a city's size and rank (1=largest, 2= second largest etc) has a power law relation. Many properties of the urban system, in addition to the rank-size rule, exhibit scaling over a considerable number of orders of magnitude, i.e. land value per land area, land value per city and the relationship between urban area and perimeter. Although the fractal nature of the urban system has been known since long, explanations as to what processes are responsible for this behavior are at best incomplete. We have developed a complex network model where nodes are taken to be fixed-size non-overlapping lots of land and connections are trade relations between economic activities in these lots. Through a connection to theory on land markets we can compare node degrees with empirically observed land value data. We obtain excellent agreement on several levels: land value per unit area, land value per city and the relationship between city area and perimeter. In addition we also show emprically that there is a linear relation between land value and population, thus making our results directly applicable to Zipf's Law of city sizes.

Joint work with Claes Andersson, Alexander Hellervik.

poster session	**Madhav V. Marathe** Los Alamos National Laboratory	Measurement and Analysis of Large Social and Infrastructure Networks
poster session	**Henning Mortveit** Los Alamos National Laboratory	Mathematical and Computational Theory of Sequential Dynamical Systems
poster session	**David A. Ostrowski** Ford Motor Company	Using Cultural Algorithms to Evolve Strategies for Recessionary Markets

Abstract: Cultural Algorithms are computational self-adaptive models which utilize a population and a belief space. In this framework, a white and black box testing strategy is embedded in order to test large-scale GP programs. The model consists of two populations, one supporting white box testing of a genetic programming system and the other supporting black box testing. The two populations communicate with each other by means of a shared belief space. This is applied to the calibration of a multi-agent system by allowing for evolution of near optimal parameters. The Cultural approach is employed to abstract coefficients of pricing strategies that are applied to a complex model of durable goods. This model simulates consumer behaviors as applied in the context of economic cycles.

Introduction Agent based techniques are known to complement standard economic theory [Axtell] Due to mathematical tractability constraints, an evolutionary framework can be successful in terms of being able to derive a solution. We have employed the utilization of a multi-agent system, MarketScape, to simulate a real-world consumer market. When we apply heterogeneous factors to the application of this market, it can be demonstrated that traditional economic theory does not hold. [Tassier] An example of this is where the postpone scenario in which consumers will delay purchase of economic goods as a function of past prices and time [Tassier] . This has been noted as affecting purchase behavior. Specific strategies by that of OEMs such as the placement of incentives are demonstrated to actually bring about a decrease in profitability. Another example involves the application of memory based techniques to that of market recession.

Here, we are interested in the application of Software Engineering techniques to that of the calibration of agent-based design. Complementary techniques of White and Black box testing are demonstrated to assist in the efficient design of software. [Ostrowski] In order to accomplish this, the White Box approach is applied to consider the implementation of specific requirements in order to guide the initial and subsequent design process. The assumption in this approach is that the results of testing can be used to guide the search for a program.

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Joint work with Robert G. Reynolds (Department. of Computer Science, Wayne State University, Detroit, Michigan).

poster session	**Timothy Schoenharl** University of Notre Dame	Agent Based Modeling Approach to Self-Organizing Neural Networks

Abstract: We explore a novel self-organizing neural network topology. We have drawn inspiration from recent research into complex networks and advances in neurobiology, and applied it towards the development of an artificial neural network. An agent based approach is used to model the neurons and their connections, providing a richness of expression not available in other neural network simulations. The agent based paradigm is well suited for our exploration, as local interaction among the neurons drives the evolution of the global network topology. We demonstrate our simulation and discuss results.

Tuesday, November 4

All talks are in Lecture Hall EE/CS 3-180 unless otherwise noted.

8:30–8:45	**Coffee**	Reception Room EE/CS 3-176

SESSION 5: MATH AND COMPUTER SCIENCE

8:45–9:20	**Tad Hogg** HP Labs	Multiagent Control of Modular Self-Reconfigurable Robots

Abstract: I'll describe how multiagent systems provide useful control techniques for modular self-reconfigurable (metamorphic) robots. Such robots consist of many modules that can move relative to each other, thereby changing the overall shape of the robot to suit different tasks. Multiagent control is particularly well-suited for tasks involving uncertain and changing environments. We illustrate this approach through simulation experiments of Proteo, a metamorphic robot system developed at PARC.

For further info: see the paper at http://arxiv.org/abs/cs.RO/0006030 or H. Bojinov et al., "Multiagent Control of Modular Self-Reconfigurable Robots", Artificial Intelligence 142:99-120 (2002).

9:20–9:55	**Zoltan Toroczkai** Los Alamos National Laboratory	Agent-Collective Optimization through Influence Network Design

Abstract: The dynamics of human, and most biological populations is characterized by competition for resources. By its own nature, this dynamics creates the group of "elites", formed by those agents who have strategies that are the most successful in the given situation, and therefore the rest of the agents will tend to follow, imitate, or interact with them, creating a social structure of leadership in the agent society. These inter-agent communications generate a complex social network with small-world character which itself forms the substrate for a second network, the action network. The latter is

a dynamic, adaptive, directed network, defined by those inter-agent communication links on the substrate along which the passed information/prediction is acted upon by the other agents. By using the minority game for competition dynamics, here we show that when the substrate network is highly connected, the action network spontaneously develops hubs with a broad distribution of out-degrees, defining a robust leadership structure that is scale-free. Furthermore, in certain, realistic parameter ranges, facilitated by information passing on the action network, agents can spontaneously generate a high degree of cooperation making the collective almost maximally efficient.

10:00–10:10	**Break**	Reception Room EE/CS 3-176

SESSION 6: PHYSICS

10:15–10:50	**Natalia Komarova** Institute for Advanced Study (Princeton) & Rutgers University	Communicating Agents in a Shared World

Abstract: We consider the problem of linguistic agents that communicate with each other about a shared world. We develop a formal notion of a language as a set of probabilistic associations between form (lexical or syntactic) and meaning (semantic) that has general applicability. Using this notion, we define a natural measure of the mutual intelligibility, $F(L, L')$, between two agents, one using the language L and the other using L'. A natural question is this: Given a language L, what language L' maximizes mutual intelligibility with L? We find surprisingly that L' need not be the same as L and we present algorithms for approximating L' arbitrarily well. Next, we consider a population of linguistic agents that learn from each other and evolve over time. Will the community converge to a shared language and what is the nature of such a language? We characterize the evolutionarily stable states of a population of linguistic agents in a game-theoretic setting. Our analysis is relevant for a number of areas in natural and artificial communication where one studies the design, learning, and evolution of linguistic communication systems.

10:50–11:25	**Filippo Castiglione** Italian National Research IAC - CNR, Rome	Large-scale Agent-Based Models: Perspectives and Requirements

Abstract: Agent Based Models (ABM) are the natural extension of the Ising or Cellular Automata-like models which have been used in the past decades to simulate various physical phenomena.

One important characteristic of ABMs, which distinguishes them from the relatively simple Ising-like models, is the complexity of the internal dynamics of each agent together with the asynchrony of the interactions among agents (and between agents and their environment).

The richness of details one can take into account in its ABM, makes such paradigm very powerful, hence appealing for the simulation of complex phenomena where the behavior of the interacting components are not safely reducible to some stylized or simple mechanism.

In my talk, I will first draw the attention to the need of a standardized method to handle the description of the agent (e.g. finite state automata) and the state-determined interaction rules.

Nowadays, the growth of interest in ABMs is strictly related to the availability of powerful computers. The large number of agents and the complexity of the internal representation of the agent in a typical simulation, dictate the use of high-performance computer-science techniques. With this respect, it is important to review some concepts related to code-optimization. Hence, I will discuss some considerations based on the experience maturated by developing and using two different ABMs, one for the simulation of the immune system activity, the second to simulate the dynamics of the price of commodities in a virtual stock market.

11:30–11:40	**Break**	Reception Room EE/CS 3-176

SESSION 7: CRITICAL INFRASTRUCTURE

11:45–12:20	**Stephen Eubank** Los Alamos National Laboratory	Social Networks and Epidemics

Abstract: EpiSims, part of the public health sector module of LANL's Urban Infrastructure Suite, is an agent-based simulation system that models the spread of disease and the effects of mitigation efforts at the level of individuals in a large urban area. This talk will briefly describe the design and implementation of EpiSims and give examples of its use. The UIS has motivated a research effort in dynamics, structure, and function of social networks. I will briefly indicate how these questions arise in EpiSims and some promising research directions.

12:20–1:55 **Lunch Break**

12:45-2:15 pm	**Random Matrices** G. Anderson and O. Zeitouni	This course (Math 8660) meets in Physics 133

1:55–2:45	**Stephen Buckley** IBM TJ Watson Research Center Helper: **Jane K. Cullum** Los Alamos National Laboratory	Discussion/Q&A Period: Sessions 1 through 4 and the poster session
2:50–2:55	**Break**	Reception Room EE/CS 3-176

Session 7: Critical Infrastructure

3:00–3:35	**Peter Schuster** Universität Wien, Austria	Modeling Molecular Evolution - The Origin of Information and Learning in Populations

Abstract: Optimization through variation and selection and other evolutionary phenomena can be studied in cell-free systems by means of populations of nucleic acid molecules, in particular ribonucleic acid molecules (RNA). Computer modeling of RNA evolution in vitro provides even deeper insights than experiments, because it allows to trace the processes in populations with full genealogical information on all molecules. Molecules, representing partially autonomous agents, multiply and produce variants through imperfect copying. Selection operates on the level of the population, chooses between variants of different reproductive success, and provides a basis for the origin of biological information as well as primitive learning. A theoretical frame for modeling molecular evolution will be presented in the lecture and several illustrative examples of simulations of evolutionary optimization will be discussed.

Reference: James P. Crutchfield & Peter Schuster, Eds. Evolutionary Dynamics - Exploring the Interplay of Selection, Accident, Neutrality, and Function. Oxford University Press, New York 2003.

3:35–3:50	**Break**	Reception Room EE/CS 3-176

SESSION 8: MATH AND COMPUTER SCIENCE

3:50–4:25	**Reinhard Laubenbacher** Virginia Bioinformatics Institute at Virginia Tech	Polynomial Models for Finite Dynamical Systems

Abstract: Substantial progress has been made in recent years toward a mathematical foundation for agent-based models. One advantage of such a foundation would be mathematical tools to relate the structure of the model to the resulting dynamics. This talk will focus on deterministic models with a finite state space, that is, finite dynamical systems. Under the assumption that the state set for the variables is a finite field, any such system can be described via a collection of polynomial functions with coefficients in the finite field. In particular, cellular automata and Boolean networks satisfy this assumption. Polynomial dynamical systems over finite fields are amenable to analysis with tools from computational algebra and algebraic geometry. They have been studied for some time in the context of control theory. A variety of (implemented) algorithms allows the algorithmic solution of problems such as reverse-engineering of systems with specified dynamics, as well as the computation of fixed points and limit cycles. Furthermore, computational algebra provides a rigorous framework in which to study the relationship between the structure of the rules/polynomials and the structure of the state space of the system. Several preliminary results will be discussed.

4:25–5:00	**Bodo Pareigis** Universität München	The Importance of Admissible Maps Between Sequential Dynamical Systems

Abstract: Sequential dynamical systems have been used to simulate many different processes. It is desirable to study their mathematical properties. Much progress has come from studying their abstract mathematical structure.

I want to show the advantages to be gained by studying also admissible maps between them.

- It is known that the full structure of a specific sequential dynamical system is known if one knows the set of all admissible maps originating in this object.

- Admissible maps are the correct definition of a simulation of one sequential dynamical system by another such system.

- Admissible maps can help to study the decomposition of a large sequential dynamical systems into small “standard” sequential dynamical systems.

- They can help to find best simulations of other systems by sequential dynamical systems.

The best presently known definition of an admissible map will be given. The properties mentioned above will be discussed.

6:30	**Workshop Dinner**	Bangkok Thai Restaurant 425 13th Avenue SE in Dinkytown, Tel (612) 331-6830.

Wednesday, November 5

All talks are in Lecture Hall EE/CS 3-180 unless otherwise noted.

8:30–8:45	**Coffee**	Reception Room EE/CS 3-176

SESSION 9: PHYSICS

8:45–9:20	**Neil F. Johnson** Oxford University	Crowd-Anticrowd Theory of Collective Dynamics in Competitive, Multi-Agent Populations and Networks

Abstract: I present a crowd-based theory describing the collective behavior within a generic multi-agent population with limited resources. These multi-agent systems – whose binary versions we refer to as B-A-R (Binary Agent Resource) collectives – have a dynamical evolution which is determined by the aggregate action of the heterogeneous, adaptive agent population. Accounting for the strong correlations between agents’ strategies, yields an accurate description of the system’s dynamics in terms of the ’Crowd-Anticrowd’ theory. This theory can incorporate the effects of an underlying network within the population, and is not just limited to the El Farol Problem and the Minority Game. By considering a variety of examples, I will show that the Crowd-Anticrowd theory offers a powerful approach to understanding the dynamical behavior of a wide class of agent-based Complex Systems [1].

[1] For applications in the financial domain, see ’Financial Market Complexity’ (Oxford University Press, June 2003).

9:20–9:55	**Alexis Arias** Icosystem Corporation	Inferring Micro-Rules from Macro-Behavior in the Minority Game

Abstract: In many real world applications of ABMs, enhancing the predictive power of the model is paramount. This requires extensive knowledge of the behavioral rules that govern the agents' actions. However, it is common to face situations where direct information, or agreement among domain experts, regarding these rules is lacking, and only output sample data (usually at an aggregate level) is available. Under these circumstances, it is important to understand whether the behavioral rules can be identified from the observable data. The identification of micro-rules from macro- behavior in ABMs when there are nonlinear interactions between agents is the subject of this presentation.

I will present results from an ongoing project designed to study the possibility of estimating individual behavioral rules in the Minority Game using sample data that exhibits different levels of aggregation. The analysis concentrates on the small sample properties of the Maximum Likelihood Estimator of individual rules. We consider two models that pose different challenges with regard to estimation and three data scenarios: panel data of individuals' actions, time series of the number of individuals in the minority, and time series of the action taken by the minority. For each scenario we study the evolution of the estimation error as the number of individuals and the size of the time series increases. In addition, we analyze the effect on the estimation error of introducing certain restrictions on the model and on the information available a priori to the modeler.

9:55–10:15	**Break**	Reception Room EE/CS 3-176

SESSION 10: MATH AND COMPUTER SCIENCE

10:15–10:50	**Madhav V. Marathe** Los Alamos National Laboratory	Sequential Dynamical Systems, Large Scale Socio-Technical Simulations and Interaction-Based Computing

Abstract: Sequential Dynamical Systems (SDS) are a special type of communicating automata that can be used to model very large socio-technical systems.

SDS based "formal simulations" potentially provide a rigorous, useful new setting for a theory of interaction-based computation. The setting is natural for comprehension of distributed systems characterized by interdependent, but separately functioning sub-parts. Massively parallel and grid computing and the associated algorithm design issues, advanced communication systems, biological networks, epidemiological processes, markets, socio-technical systems are examples of such systems.

I will focus on the computational aspects of SDS. The concepts and results shed light on the computational complexity of computing phase space properties of SDS. Applicability of these concepts will be described in the context of large scale socio-technical simulations being developed in our group at the Los Alamos National Laboratory.

10:50–11:25	**Samson Abramsky** Oxford University Computing Laboratory	The Logic and Geometry of Agents

Abstract: We describe some perspectives on systems of interacting agents which have arisen in recent work on Game Semantics and Geometry of Interaction. We show how types and logical structure can be used to enforce compositional behaviour, so that we can plug several sub-systems of agents into a compound system with more complex behaviour in a disciplined fashion.

We also show how very simple 'copy-cat' agents can be composed to yield a universal model of computation, of a strikingly geometric nature. This model also has connections with reversible and quantum computation.

11:30–11:40	**Break**	Reception Room EE/CS 3-176

SESSION 11: ECONOMICS AND MARKETS

11:45–12:20	**Marija D. Ilic** Carnegie Mellon University	A Multi-Agent Based Approach to Modeling and Analyzing Spot Electricity Markets

Abstract: This talk is based on the joint work with Dr Poonsaeng Visudhiphan and my current graduate student Zhyiong Wu. In the first part of this talk a model derived in the PhD thesis of Dr Visudhiphan is briefly reviewed, and simulations are presented to illustrate electricity prices resulting from this model under several bidding strategies. The results are analyzed and compared with the results obtained using two well-known AI learning techniques. An important conjecture concerning equilibrium results as a function of system demand level is stated and illustrated. The second part of the talk highlights the importance of physical constraints on bidding strategies and market power. In particular, it is shown how the unit-commitment constraints, reflected in start-up and shut down costs and rates of various generation technologies, are likely to make the bidding logic much more difficult, and almost impossible. Finally, a generalized definition of market power in electricity markets as a measure of market inefficiencies with the physical constraints accounted for is suggested. Physical and financial risks are assessed using this generalized notion.

Joint work with Poonsaeng Visudhiphan, Zhyiong Wu.

12:20–1:55	**Lunch Break**	
2:00–3:00	**Don Hush** Los Alamos National Laboratory Helper: **Gabriel Istrate** Los Alamos National Laboratory	Discussion/Q&A Period: Sessions 5 through 8
3:00–3:15	**Break**	Reception Room EE/CS 3-176

SESSION 12: CRITICAL INFRASTRUCTURE

3:15–3:50	**Richard M. Fujimoto** Georgia Institute of Technology	

Abstract: Parallel and distributed simulation tools are emerging that offer the ability to perform detailed, packet-level simulations of large-scale networks. This capability offers enormous new opportunities for researchers to perform simulation experiments on networks of a scale that could not be completed previously. At the same time, it also creates challenges to the research community to define scenarios and configurations that are realistic relative to current and future Internet configurations. It creates challenges to tool builders to develop verified and validated simulators that are easy to use and which execute efficiently on parallel and distributed computers over a wide range of network configurations and scenarios. This presentation will quantitatively characterize the state-of-the-art in large-scale network simulation. An approach to realizing scalable network simulations that leverages existing sequential simulation models and software will be described. A recent performance study is described concerning large-scale network simulation on a variety of platforms ranging from workstations to cluster computers to supercomputers.

This research represents joint work of the speaker with Drs. Mostafa Ammar, Kalyan Perumalla, George Riley and several graduate students at Georgia Tech.

3:50–4:25	**Christian Reidys** Los Alamos National Laboratory	Certain Morphisms of Dynamical Systems

Abstract: We study a class of discrete dynamical systems that consists of the following data: (a) a finite (labeled) graph Y with vertex set 1...n where each vertex has a binary state, (b) a vertex labeled multi-set of functions $(F_(i,Y) : F_2^n \to F_2^n)_i$ and (c) a permutation p. The function $F_(i,Y)$ updates the binary state of vertex i as a function of the states of vertex i and its immediate Y-neighbors and leaves the states of all other vertices fixed. The permutation p represents a Y-vertex ordering according to which the functions $F_(i,Y)$ are applied. By composing the functions $F_(i,Y)$ in the order given by p we obtain the sequential dynamical system (SDS). Let G be the graph representing the phase space of the SDS. A SDS-morphism between the two SDS $[F_Y, p]$ and $[F_Z, s]$ is a triple consisting of a graph morphism $v : Y \to Z$, a map

$e : S_z \to S_y$, where z,y denote the cardinalities of Z and Y, respectively such that e(s)=p and finally a digraph morphism between G(Z) and G(Y). Our main result is that any locally bijective graph morphisms (coverings) between dependency graphs of SDS naturally induce SDS-morphisms and we further give applications of this theorem that allow to identify variuos phases space properties of SDS.

4:30–5:30 **Computer Demos**

Thursday, November 6

All talks are in Lecture Hall EE/CS 3-180 unless otherwise noted.

8:30-8:45 **Coffee** Reception Room EE/CS 3-176

SESSION 13: MATH AND COMPUTER SCIENCE

8:45–9:20 **Dirk Helbing**
nstitute for Economics and Traffic, Dresden University of Technology, Germany
Agent-Based Simulation of Traffic Jams, Crowds, and Supply Networks

Abstract: Why are vehicles sometimes stopped by so-called "phantom traffic jams", although they all like to drive fast? What are the mechanisms behind stop-and-go traffic? Why are there several different kinds of congestion, and how are they related? Why do most traffic jams occur considerably before the road capacity is reached? Can a temporary reduction of the traffic volume cause a lasting traffic jam? All of this is important to understand from the perspective of intelligent transportation systems. Surprisingly, speed limits can speed up traffic under certain conditions, and traffic lights at on-ramps can reduce the overall travel times. Driver assistance systems have a particularly high potential. And decision experiments are carried out in order to learn re-routing strategies which do not invalidate traffic forecasts.

A lot has also been learned about pedestrian streams. In particular, we understand why pedestrians moving in opposite directions normally organize in lanes, while similar systems are "freezing by heating". In other cases, one observes fluctuation-induced ordering, oscillations of the flow direction at bottlenecks, rotary traffic, or herding effects. We also understand why panicking pedestrians produce dangerous deadlocks and how these can be avoided by a skillful design of buildings. These insights can be applied to optimize production processes.

9:20–9:55 **William Y. C. Chen**
Nankai University
Evaluation of the NOR Sequential Dynamical Systems, *Presented by:* Henning S. Mortveit, Los Alamos

Abstract: We obtain an evaluation theorem for the sequential dynamical systems (SDS) based on the dependency graph G and the NOR update function. The importance of the NOR-SDS lies in both practical and theoretical considerations. From the graph theoretical point of view, the fixed points and Gardens-of-Eden of NOR-SDS are closely related to the independent sets of the underlying graph, as discovered by C. Reidys. Our evaluation theorem serves as a simplified algorithm of the update scheme given by the original definition.

Joint work with C.L. Barrett (Los Alamos National Laboratory, CCS-5, MS M997, Los Alamos, NM 87548, USA, barrett@lanl.gov and Michelle J. Zheng (Center for Combinatorics, LPMC, Nankai University, Tianjin 300071, P.R. China) zheng@eyou.com.

10:00–10:05 **Break** Reception Room EE/CS 3-176

SESSION 13: MATH AND COMPUTER SCIENCE

10:10–10:55	**David H. Wolpert** NASA Ames Research Center	From Game Theory to Distributed Control and Back Again

Abstract: Product Distribution (PD) theory is a powerful new formalism with potential applications throughout science. This talk starts by presenting PD theory in the context of conventional, full-rationality game theory. PD theory is then used to extend conventional game theory, by deriving the information-theoretic formulation of bounded rational game theory. Next the close relationship of that formulation with the canonical ensemble of statistical physics is delineated. This in turn leads to the application of PD theory to distributed control of multi-agent systems. As the audience prefers and time allows, the talk will end with a discussion of PD theory applied to distributed optimization, evolutionary game theory, numerical integration, sampling of probability densities, or management theory.

11:00–11:50	**Peter F. Stadler** Universität Leipzig, Germany/ Universität Wien, Austria Helper: **Henning S. Mortveit** Los Alamos National Laboratory	Discussion/Q&A Period: Sessions 9 through 13
11:50–12:30	**Workshop Wrap-Up and Follow-On Discussion**	
12:30	**End of "Hot Topics" Workshop**	

12:45-2:15 pm	**Random Matrices** G. Anderson and O. Zeitouni	This course (Math 8660) meets in Physics 133

Friday, November 7

The 10:30 IMA break will be in Lind Hall 400.

Monday, November 10

The 10:30 IMA break will be in Lind Hall 400.

Tuesday, November 11

The 10:30 IMA break will be in Lind Hall 400.

IMA POSTDOC SEMINAR, Lind Hall 409:

11:15-12:15 am	**Tom Kurtz** University of Wisconsin	Introduction to Martingale Problems

Abstract: The generator for a Markov process is a linear operator that characterizes infinitesimally the evolution of the distribution of the process. Classically, the Hille-Yosida theory of operator semigroups was used to connect the Markov process to its generator. In the context of diffusion processes, Stroock and Varadhan showed that Markov processes can be characterized by the requirement that certain functionals of the process, determined by the generator, must be martingales,

that is, the Markov process can be characterized as the unique solution of a martingale problem. For example, Brownian motion is the unique solution of the martingale problem for the Laplacian.

Martingale problems provide a powerful approach to the study of Markov processes. The basic theory of martingale problems will be reviewed and several illustrative examples of its application will be given.

NOTE: This talk is intended to give some useful background for the November 12 talk in the Complex Systems Seminar.

The IMA Postdoc Seminar is organized by Balaji Gopalakrishnan and Antar Bandyopadhyay.

12:45-2:15 pm	**Random Matrices** G. Anderson and O. Zeitouni	This course (Math 8660) meets in Physics 133

Wednesday, November 12

The 10:30 IMA break will be in Lind Hall 400.

BROWN BAG SEMINAR, Lind Hall 409:

12:00	**Tim Garoni** IMA	Impenetrable Bosons, Random Matrix Averages and Log-Gases

Abstract: See http://www.ima.umn.edu/for abstract

The IMA Brown Bag Seminar is organized by
Tim Garoni and Tamon Stephen.

COMPLEX SYSTEMS SEMINAR, Lind Hall 409:

2:30 pm	**Tom Kurtz** University of Wisconsin	Infinite Population Models in Population Genetics

Abstract: The simplest model of population genetics assumes that each new generation is obtained by sampling with replacement from the previous generation. Models including mutation, selection, and recombination are obtained as perturbations of the basic sampling model. Population geneticists noted early on that infinite population approximations simplified computations. Two radically different approximations emerged. Diffusion approximations suggested by Feller provide a model for the evolution of gene or type frequencies forward in time, and the extension of these models to complex type spaces has led to the development of measure-valued models. The coalescent models introduced by Kingman describe the ancestral relationships going backward in time. Models that capture both the coalescent structure and the diffusion of type frequencies and allow exploitation of one to study the other will be described.

Thursday, November 13

The 10:30 IMA break will be in Lind Hall 400.

12:45-2:15 pm	**Random Matrices** G. Anderson and O. Zeitouni	This course (Math 8660) meets in Physics 133

Friday, November 14

The 10:30 IMA break will be in Lind Hall 400.

Monday, November 17

IMA Workshop:

Networks and the Population Dynamics of Disease Transmission

17-21 November 2003
Organizers: Martina Morris (University of Washington), Claudia Neuhauser (University of Minnesota),

See http://www.ima.umn.edu/complex/fall/c3.html

Infectious diseases are transmitted from person to person, so our understanding of disease transmission is rooted in a theory of population transmission dynamics. For Sexually Transmitted Diseases (STDs) or Blood Borne Infections (BBIs), where transmission requires an exchange of body fluids, the structure of the contact network plays a particularly critical role. The contact network can be represented as a graph, where the persons are nodes, and the partnerships are edges. Simple mathematical models of disease transmission dynamics through such networks have provided a number of insights through simulation that have led to changes in STD control strategies. Much work has been done in the last 15 years to model HIV transmission, and to collect survey data on the partnership networks. But the link between data and models is still problematic. Random graph models, and the techniques for estimating them, are the natural solution. A class of statistical exponential family models for random graphs has recently been adapted from the spatial statistics literature for social networks. Markov Chain Monte Carlo (MCMC) techniques can be used for likelihood-based and Bayesian inference. MCMC can also be used to simulate the network for given parameters, thus linking the network data to the network simulation. This workshop will cover the recent advances in network modeling, with applications to disease prevention and other social science fields. Networks, and their associated population dynamics, have a broad range of applications in both the social and physical sciences. The natural audience includes statisticians, epidemiologists, graph theorists, sociologists, and those in bio-behavioral health, ecology and evolutionary biology.

All talks are in Lecture Hall EE/CS 3-180 unless otherwise noted.

8:30	**Coffee and Registration**	Reception Room EE/CS 3-176
9:15	**Douglas N. Arnold, Scot Adams, and Organizers**	Welcome and Introduction
9:30	**Denis Mollison** Heriot-Watt, Edinburgh	Small Worlds and Giant Epidemics

Abstract: Key problems for models of disease spread relate to threshold, velocity of spread, final size and control. All of these depend crucially on the network structure of individual interactions.

Networks of interest range from the local extreme where interactions are only between nearest neighbours in some low dimensional space, and the infinite-dimensional 'mean-field' extreme where all interact equally with all. Intermediate cases of practical interest include 'small-world' and meta-population models.

I shall discuss the various structures of such models, their similarities and differences, and some approximations to them. The main aim is to identify what features of contact structure need to be captured when formulating a model for any specific problem of disease spread.

10:20	**Discussion**	

10:30	**Coffee Break**	Reception Room EE/CS 3-176
11:00	**Duncan Watts** Columbia University	Universal Behavior in a Generalized Model of Contagion

Abstract: Contagion processes are widely observed and studied in biology and the social sciences. In epidemiological models, contact between an infected and a susceptible individual is assumed to result in transmission with a probability that is independent of any previous contacts (i.e., infection is memoryless), whereas in social contagion the memory of prior exposures may dramatically influence an individual's likelihood of adopting a new idea, product, etc. Here we introduce a model of contagion which incorporates memory of infectious contacts with infection occurring when a critical threshold has been exceeded. We study in detail a simple special case of the general model, finding that for homogeneous population, two universal classes of behavior exist corresponding to the behavior of traditional *epidemic threshold* models and *critical mass* models. The behavior of heterogeneous populations can be understood as combinations of these two classes. We find that even a slight violation of the independence assumption can dramatically alter the equilibrium state of an epidemic or result in multiple stable and unstable equilibria. We suggest how these findings may lead to different intervention strategies for preventing or triggering epidemics.

11:50	**Discussion**	
12:00	**Lunch Break**	
1:30	**Stephen Eubank** Los Alamos National Laboratory	Structural Aspects of Massive Social Networks

Abstract: We describe the estimation of very large, realistic social contact networks and study their structural properties. As a specific example, we consider the social network for the city of Portland, Oregon, developed as a part of the TRANSIMS/EpiSims project at the Los Alamos National Laboratory. The most complete description of the network is a bipartite graph, with two types of nodes: people and locations; where edges represent people visiting locations on a typical day. We describe various computationally tractable projections and approximations of this network and compare their structural properties.

2:20	**Discussion**	
2:30	**Coffee Break**	Reception Room EE/CS 3-176
3:00	**Second Chances**	Speakers of the day respond to further questions, suggestions, re-frame their main points, look toward future directions.
3:30	**Group Photo**	
3:40	**IMA Tea and more (with Poster Session)**	IMA East, 400 Lind Hall
poster session	**David C. Bell** Affiliated Systems Corporation, Houston	The HIV Transmission Gradient

Abstract: Of critical importance in the transmission of HIV are "gatekeepers," the HIV-negative partners of persons who are HIV-infected. These are the persons at risk and they are the persons who can eventually spread the disease further. And since the highest infectivity comes in the first months after infection, usually before knowledge of infection, the behavior of these "gatekeepers" while they are HIV- is critical. In a sample of 267 persons from high drug use neighborhoods, we collected data on 3254 relationships involving 1271 other persons. We quantitatively describe the gradient of infection potential by which HIV can diffuse from the HIV+ population through "gatekeepers" to the rest of the population through both drug injection behaviors and sex behaviors.

poster session **Rodney J. Dyer** The Shape of Genetic Structure: A Graph-Theoretic Analysis of Global Human Genetic Structure
Iowa State University

Abstract: The amount and geographic patterning of human genetic variation is an evolutionary consequence of several historical and contemporary processes including population expansion, demographic subdivision, and migration. Quantifying this variation, and in turn the extent to which these forces have acted in shaping human genetic structure is a key component to understanding the evolution of human populations. Here I present an analysis framework based upon graph-theory, which we call Population Graphs (PG). While the PG framework allows the extraction of traditional population genetic statistics such as differentiation (Φ_{ST}) and isolation by distance ($\hat{M}$), topological analysis of the connectedness among human populations provides heretofore-unattainable information on intra-population evolutionary history. I highlight the utility of the PG framework using data consisting of 1056 individuals assayed for 376 variable microsatellite loci sampled from 52 populations around the globe. An analysis of the topology of the human graphs reveals the following characteristics of human population genetic structure. First, groups of populations exhibit significant topological structuring consistent with geographically relevant population subdivisions. Second, the topological distances among populations are significantly correlated with geographic separation supporting the notion of isolation by distance and spatially proximate migration patterns. Finally, we show how the topology of the graph is used to identify specific populations whose patterns of connectivity prove to be critical to the movement of genetic information across the entire graph.

poster session **Ken Eames** Contact Tracing and Disease Control
University of Cambridge

Abstract: Contact tracing, followed by treatment, is a key control measure in the battle against infectious diseases. It represents an extreme form of locally targetted control, a hyper-parasite acting on infection, and as such has the potential to be highly efficient, especially when dealing with low numbers of cases. Modelling contact tracing requires explicit information about the transmission pathways from each individual and hence the network of contacts. Using pair-wise approximations and full stochastic simulations to model network-based processes, the utility of contact tracing is investigated. A simple relationship between the efficiency of contact tracing necessary to eradicate infection and te basic reproductive ratio of the disease is shown to hold in a wide variety of scenarios. Only clustering within the transmission network is found to destroy this relationship, enhancing the effectiveness of contact tracing by providing alternative tracing pathways. Since the critical efficiency depends on the characteristics of individuals within the network, applying different tracing regimes within differing subpopulations can achieve the elimination of infection whilst lowering the burden on health care services.

poster session **Simon Frost** Simulation of Epidemiological Models on Networks
University of California, San Diego

Abstract: Individual- or agent-based simulations are useful tools for understanding how the spread of an infectious agent or computer virus is affected by the structure of the underlying contact network and by the natural history of infection at an individual level. Spurred by the lack of freely available software to simulate epidemic processes on networks, we are developing a package, Epydemic, based upon SimPy (http://simpy.sourceforge.net), an open-source discrete-event simulation library written in Python, that permits the rapid prototyping of epidemic models. Infections consisting of multiple stages are easily and concisely modeled using semi-coroutines. The software includes a graphical user interface for parameter entry, result visualization etc., and an interactive console that allows the user to directly analyze components of the simulation. The poor performance normally associated with the use of an interpreted language for simulation is compensated for; by the use of efficient algorithms for the contact process and for the scheduling of events; by run-time compilation; by the use of extension modules programmed in C; and by parallelization of model runs using the Message Passing Interface. We present an example of a standard SIR model spreading in a configuration graph.

Joint work with Klaus G. Muller.

poster session	**Matthew Salganik** Columbia University	Sampling and Estimation in Hidden Populations Using Respondent-Driven Sampling

Abstract: The task of slowing the spread of HIV is complicated by our difficulties in collecting accurate information about certain key subpopulations, such as injection drug users and commercial sex workers. Using a new sampling and estimation method called respondent-driven sampling, researchers are now able to collect information about some of these key subpopulations more quickly, cheaply, and accurately than before.

A respondent-driven sample is selected with a snowball-type design (sample members recruit their friends). Despite the numerous biases inherent in this sample selection process, an estimation procedure is developed which, under specified (and quite general) conditions, can be used to make unbiased estimates about the proportion of the population with a specific trait – for example the percentage of injection drug users in a city with HIV. The estimation procedure uses the sample to make inference about the social network connecting the subpopulation. This network information is then used to make inference about the characteristics of the subpopulation. It is also the case that these estimates are asymptotically unbiased no matter how the seeds (initial members of the sample) are selected.

poster session	**Anne Schneeberger** Imperial College, London	Sacle-free Networks and Sexually Transmitted Diseases: A Description of Observed Patterns of Sexual Contacts in Britain and Zimbabwe

Abstract: Sexually transmitted infections spread through a network of contacts created by the formation of sexual partnerships. Methods developed in physics can characterise a wide range of networks through a description of the distribution of numbers of sex partnerships. It has been suggested that in the Swedish population this 'degree' distribution follows a power law and therefore indicates a 'scale-free' network. Our objectives were to test statistically whether distributions of numbers of sexual partners reported by different populations and over different time periods are well described by power laws and to estimate their exponent and its implications. Maximum likelihood estimates of the exponent of a scale free network fitted to reported distributions of numbers of partners are compared with the fit for an exponential null model. Data are taken from 4 population based surveys, three from Britain and one from rural Zimbabwe. We find that the networks can be described by a power law over a number of orders of magnitude. In addition, exponents differ significantly and meaningfully, with an 'accelerating network' formed between men who have sex with men (MSM). Networks with an exponent indicating the lack of a 'critical spread rate' are also found for the other populations except for women in Britain. Thus statistical analyses demonstrate that a scale-free network approach provides a reasonable description of distributions of reported numbers of sexual partners. Further, if these networks are formed over a short time only a very small transmission probability will be sufficient to lead to persistence of infection.

poster session	**Markus Schwehm** University of Tübingen, Germany	Stochastic Simulation of Epidemics on Large Contact Networks

Abstract: We have implemented a fast stochastic individual-based simulator the analysis of disease transmission and containment interventions. The simulator consists of a discrete event simulator for the processing of event-based models and plug-ins for different contact network topologies.

The discrete event simulation distinguishes tree types of events. The first type implements the standard SEIRS infection dynamics with susceptible, exposed, infectious and recovered states as well as vaccination and a simple birth/death process. The second type models the visibility of the disease according to none, detectable or obvious symptoms. The third type allows to model intervention strategies (like contact tracing, quarantine and case isolation), which influence the contact structure of individuals. Events can trigger further events for the same individual and via the contact network for other individuals. All events are processed in a discrete event simulator which is optimized for large numbers of events using a priority queue (indirect heap algorithm) and can process about 50.000 events per second.

The inhabitants of the population are represented by their internal state (infection, symptom and contact status) and represent nodes in a contact network. The modular design allows to exchange the contact network independent of the chosen discrete event model. For each individual the contact network allows to identify a limited number of contacts for transmission of the infection or for implementing contact tracing interventions. Currently there exist parameterized network generators for local, global, random and scalefree contact networks. Moreover, the data struc-ture allows to maintain arbitrary networks consis-ting of several independent layers. We were able to simulate populations of two million individuals

on a personal computer.

Joint work with Martin Eichner.

Tuesday, November 18

All talks are in Lecture Hall EE/CS 3-180 unless otherwise noted.

9:00	**Coffee**	Reception Room EE/CS 3-176
9:30	**Marie-Claude Boily** Imperial College, London	The Limits of Sexual Network Data: Implications for Mathematical Modelling of STI

Abstract: Empirical and theoretical studies have highlighted the importance of the local (egocentric) and the global (sociocentric) network structure on the individual risk of infection and the spread of diseases in populations. Transmission dynamics models of STI (sexually transmitted infection) and HIV/AIDS have been instrumental in highlighting the importance of quantifying sexual behaviour such as the average and variance in sexual activity, the mixing pattern, concurrency and others in order to understand epidemiological trends. Detailed individual based models of partnership formation and dissolution (micro-simulation or network models) are increasingly being used in order to capture the full complexity of sexual networks and "more realistically" simulate the course of STI and HIV/AIDS. However, at the moment, the complexity of models has outstripped the level of behavioural data currently available for most populations.

The objective of the talk is to review and discuss the limits of currently available sexual network data and the implication for mathematical modelling of STI. It will be shown how the limited network data available, compounded by our incomplete understanding of individual behaviour, has a number of consequences for the formulation and validation of network models, the interpretation of model results, and the formulation of research questions and data collection. In the case of a lethal disease, like HIV/AIDS, not only is it important to understand the impact of the network structure on the spread of disease, but is it also important to understand and assess the impact of the spread of disease on the network structure. It will be shown that this is particularly relevant to understand the different impacts of antiretroviral therapy or vaccination in heterogeneous populations largely afflicted by the epidemic.

10:20	**Discussion**	
10:30	**Coffee Break**	Reception Room EE/CS 3-176
11:00	**Martina Morris** University of Washington	The Influence of Concurrent Partnerships on Network Structure and Transmission Dynamics

Abstract: Concurrent partnerships are defined as partnerships that overlap in time, rather than obeying the norm of sequential monogamy. Concurrency changes the structure of a sexual partnership network, creating larger components and providing an ecology that favors the rapid spread of infectious pathogens. Simulation studies have demonstrated that concurrent partnerships can increase the speed and pervasiveness of spread in a population, even when the number of partnerships is held constant. Empirical studies have shown that concurrency is associated with higher levels of transmission. Thus, there is growing evidence that concurrency may play an important role in explaining the differentials in prevalence across population subgroups. This study uses three nationally representative data sets to identify the levels and variation of concurrency in the US, Thai, and Ugandan populations. Both the levels and the patterns of concurrent partnerships are very different in these populations. Simulation based on these patterns show transmission dynamics that replicate the observed variation in prevalence.

11:50	**Discussion**

12:00	**Lunch Break**	

12:45-2:15 pm	**Random Matrices** G. Anderson and O. Zeitouni	This course (Math 8660) meets in Physics 133

1:30	**James Moody** Ohio State University	Epidemic Potential in Human Sexual Networks: The Development of STD Cores.
2:20	**Discussion**	
2:30	**Coffee Break**	Reception Room EE/CS 3-176
3:00	**Second Chances**	Speakers of the day respond to further questions, suggestions, re-frame their main points, look toward future directions.
3:30	**Walk**	Walk along the Mississippi, weather permitting
4:45	**M. Handcock, J. Tantrum** University of Washington	Demonstration of Latent Space Models, 409 Lind Hall

Wednesday, November 19

All talks are in Lecture Hall EE/CS 3-180 unless otherwise noted.

9:00	**Coffee**	Reception Room EE/CS 3-176
9:30	**Phillipa Pattison** University of Melbourne	Neighbourhood-based Models for Social Networks: Model Specification Issues

Abstract: Pattison and Robins (2002) argued that social networks can be modelled as the outcome of processes that occur in overlapping local regions of the network, termed local social neighbourhoods. Within this framework, each neighbourhood is conceived as a possible site of interaction and is associated with a subset of possible network ties. Global network structure is then hypothesised to arise as the outcome of processes occurring within these overlapping local neighbourhoods. In this paper, we review theoretical arguments for various hypotheses about the forms of these local neighbourhoods. We consider Markovian neighbourhoods as well as generalized realisation-dependent neighbourhoods that are generated, in part, by interactive network processes themselves. We introduce some promising new neighbourhood forms including what we term k-triangles, multiple triadic structures sharing a common dyadic base. We also introduce hypothesized relationships between parameters representing related neighbourhood structures, such as k-stars or k-triangles, and thereby obtain simplified model specifications. Illustrative empirical analyses based on these various model specifications are presented.

Reference: Pattison, P., & Robins, G. L. (2002). Neighbourhood-based models for social networks. Sociological Methodology, 32, 301–337.

10:20	**Discussion**	
10:30	**Coffee Break**	Reception Room EE/CS 3-176
11:00	**Garry Robins** The University of Melbourne, Australia	Exponential Random Graph (p*) Models for Social Networks: The Global Outcomes of Local Model Specifications

Abstract: Exponential random graph models, when derived from a dependence graph using the Hammersley-Clifford theorem, are specified in terms of local network structures. But as these localized patterns agglomerate, the global outcomes are often not apparent. We review our recent work on simulating distributions of Markov random graphs, examining the resulting global structures by comparison with appropriate Bernoulli distributions of graphs. We provide examples of various stochastic global "worlds" that may result, including small worlds, long path worlds and dense non-clustered worlds with many four-cycles. Degeneracy in these models relates to the movement from structure to randomness, when parameter scaling results in a phase transition occurring at a certain "temperature". Degenerate or "frozen" deterministic structures may be merely empty or full graphs, but also include more interesting highly clustered "caveman" graphs, bipartite structures, and global cyclic structures involving structurally equivalent groups.

But Markov random graphs are only one possible way to specify exponential random graphs. We present recent results from simulations for two other new model specifications. The first specification includes binary attribute measures on the nodes, with network ties and actor attributes mutually contingent, resulting in joint social influence/social selection models. The second specification includes aggregations of triangle and star counts, permitting an explicit model form for the degree distribution and a new transitivity concept, k-triangles, reflecting the distribution of triangles across the graph.

11:50	**Discussion**	
12:00	**Lunch Break**	
1:30	**Richard Rothenberg** Emory University School of Medicine	Large Network Concepts and Small Network Characteristics

Abstract: The characteristics of large networksdegree distribution, small world phenomena, community structure, assortatitivity, clustering, vulnerability to attack, etc.may not be fully recognizable in the smaller (by 5-7 orders of magnitude) networks within which disease transmission takes place. The smoothing afforded by size may not protect small network from unpredictable manifestations that result from underlying heterogeneity and attendant sampling variability. To explore the characteristics of small networks, we have assembled 15 data sets from completed network studies that focused on the transmission of STDs and HIV. These studies reveal underlying heterogeneity in their demographic characteristics, risk behaviors, and disease prevalence, but some similarities with regard to degree distribution, clustering and, depending on the predominant risks, assortatitivity. For example, the aggregated degree distribution (a composite totaling $> 14,000$ dyads) is scale-free (that is, the Cumulative Probability Distribution is linear in the log-log scale, thus fitting a power law curve with an coefficient of ~ 2.0), as are most of the degree distribution for individual studies (albeit with considerably more noise). Clustering greater than that predicted for random graphs is present in all the network studies that permitted examination of components. Short mean path lengths between persons within components, a manifestation of the small world effect, are universally present. Such observations provide substantiation that small networks may behave similarly to large ones, despite greater variability and sampling uncertainties and provide some empirical validation of the theoretical basis for an apparent lack of epidemic threshhold and continued low level endemic disease transmission of some STDs and HIV in these microsettings.

2:20	**Discussion**	

2:30	**Coffee Break**	Reception Room EE/CS 3-176
3:00	**Second Chances**	Speakers of the day respond to further questions, suggestions, re-frame their main points, look toward future directions.
4:00	**David R. Hunter** Penn State University	Fitting Exponential Random Graph Models via Maximum Likelihood, 409 Lind Hall

Abstract: There is increasing interest in modeling network data using exponential random graph models (ERGMs). Fitting these models using traditional methods such as maximum likelihood is difficult if not impossible due to the fact that evaluation of the likelihood function involves a summation with a very large number of terms. This talk discusses a method that uses stochastic approximation of the likelihood function based on a Markov chain Monte Carlo (MCMC) approach. An alternative approach known as maximum pseudolikelihood is also discussed.

6:00	**Workshop Dinner**	Location: TBA

Thursday, November 20

All talks are in Lecture Hall EE/CS 3-180 unless otherwise noted.

9:00	**Coffee**	Reception Room EE/CS 3-176
9:30	**Mark S. Handcock** University of Washington	Social Networks Models: Inference and Degeneracy

Abstract: We consider statistical and stochastic models for graphs that can be used to represent the structural characteristics of network. To date, the use of graph models for networks has been limited by three interrelated factors: the complexity of realistic models, paucity of empirically relevant simulation studies, and a poor understanding of the properties of inferential methods. In this talk we discuss solutions to these limitations. We emphasize the important of likelihood-based inferential procedures and role of Markov Chain Monte Carlo (MCMC) algorithms for simulation and inference. A primary ongoing issue is the identification of classes of realistic and parsimonious models. In this regard show the unsuitability of some commonly promoted Markov models classes because they can result in degenerate probability distributions. The ideas are motivated and illustrated by the study of sexual relations networks with the objective of understanding the social determinants of HIV spread.

10:20	**Discussion**	
10:30	**Coffee**	Reception Room EE/CS 3-176
11:00	**Peter Hoff** University of Washington	Mixed Effects Models for Network Data

Abstract: One impediment to the statistical analysis of network data has been the difficulty in modeling the dependence among the observations. In the very simple case of binary (0–1) network data, some researchers have parameterized network dependence in terms of exponential family representations. Accurate parameter estimation for such models is difficult, and the most commonly used models often display a significant lack of fit. Additionally, such models are generally limited to binary data. In contrast, mixed effects models have been a widely successful tool in capturing statistical dependence for a variety of data types, and allow for prediction, imputation, and hypothesis testing within a general regression

context. We propose novel random effects structures to capture network dependence, which can also provide graphical representations of network structure and variability.

11:50 **Discussion**

12:00 **Lunch Break**

12:45-2:15 pm **Random Matrices** This course (Math 8660) meets in Physics 133
G. Anderson and O. Zeitouni

1:30 **Tom A.B. Snijders** Simulation-Based Statistical Inference for Evolution of Social Networks
University of Groningen

Abstract: Social networks are structures of social ties between individuals (or other social actors, e.g., companies or countries). The most common representation of a social network is a directed graph, with individuals as nodes, in which the arcs indicate for each of the ordered pairs of individuals whether the tie in question (e.g., friendship) is present or not. In addition, there can be covariate data, referring to the individuals or the dyads (ordered or unordered pairs of nodes).

Social mechanisms can be brought to light much better using longitudinal observations on social networks, than by using single observations. The most common type of longitudinal observations are repeated measures, or panel data. Repeated measures on social networks represent a complicated data structure. Computer simulation offers fruitful possibilities here, because it greatly expands the scope of modeling beyond the models for which likelihood and other functions can be analytically calculated. Continuous-time models are more appropriate for modeling longitudinal social network data than discrete-time models because of the endogenous feedback processes involved in network evolution.

Probability models for the evolution of social networks are discussed which are based on the idea of actor-oriented modeling: the nodes in the network represent actors who change their relations in a process of optimizing their "objective function", plus a random component representing unexplained change. The resulting model constitutes a continuous-time Markov chain, and can be simulated in a straightforward manner. Similar models can be proposed which are tie- oriented, in which ties can change randomly as a result of optimizing an objective function. In all these models, the change in the network is modeled as the stochastic result of network effects (reciprocity, transitivity, etc.) and effects of covariates. The model specification is given by the rate function, defining the rate at which ties may change; the objective function, indicating the "preferred" state of the network; and the gratification function, representing change tendencies for which the drive for creation of a new tie is not the opposite of the drive for deletion of this tie when it exists. These three functions may depend on endogenous and/or exogenous actor and dyad characteristics.

The parameters of this model are weights in the rate, objective, and gratification functions, which may depend on network structure and on covariates. The parameters can be estimated using a stochastic version of the method of moments, implemented by a Robbins-Monro-type algorithm. An example is given of the evolution of the friendship network in a group of university freshmen students.

Elaborations which may be discussed include alternative model specifications and alternative estimation methods. Further information about this research is at http://stat.gamma.rug.nl/snijders/siena.html.

2:20 **Discussion**

2:30 **Coffee Break** Reception Room EE/CS 3-176

3:00	**Second Chances**	Speakers of the day respond to further questions, suggestions, re-frame their main points, look toward future directions.
5-6:30	**IMA Reception**	IMA East, 400 Lind Hall
7:00 pm	**IMA Public Lecture:** **Richard A. Tapia** (CAAM), Rice University	Math at Top Speed: Breaking Myths in the Drag Racing Folklore Smith Hall 100 Co-sponsored by the IT Alumni Society (ITAS). See http://www.ima.umn.edu/public-lecture/2003-04/tapia/.

Abstract: Throughout his life, either as participant, support individual, or involved spectator, the speaker has been involved in some aspect of drag racing. As such he has witnessed the birth and growth of many myths concerning dragster speed and acceleration. In this talk the speaker uses his mathematical training to identify rather elementary mathematical frameworks for the study of a particular popular belief and then applies mathematics to better understand the belief at hand. In this manner some myths are explained and validated, while others are destroyed. Included in these examples will be attempts to determine how fast dragsters are really going and what is the maximum acceleration achieved by today's dragsters? The speaker will explain why dragster acceleration is greater than the acceleration due to gravity, an age-old inconsistency. The first part of the talk will be a historical account of the development of the sport of drag racing and will include shots of various family members. A component of the presentation will be several lively videos used to illustrate points.

Friday, November 21

All talks are in Lecture Hall EE/CS 3-180 unless otherwise noted.

9:00	**Coffee**	Reception Room EE/CS 3-176
9:30	**Alden S. Klovdahl** Australian National University	Big Worlds, Isolated Individuals: Some Characteristics of Social Networks of Ordinary People

Abstract: Belief in the idea of a 'small world' as applied to human societies lacks empirical support. Even the data that originally gave rise to this idea (Milgram) does not support it. The purpose here is to consider some characteristics of social networks of randomly selected (Table of Random Numbers) ordinary urban residents as a first step away from speculations about networks in modern societies towards solid empirical evidence. Measures presented will include graph- theoretic mean and median distances, and eccentricities. At the core of this work is the presupposition that to more fully understand factors affecting the spread of many human pathogens it is necessary to be able to accurately characterize the underlying population networks through which they can be transmitted.

10:20	**Discussion**	
10:30	**Coffee**	Reception Room EE/CS 3-176
11:00	**Stephen P. Borgatti** Boston College	Issues in Identifying Structurally important Nodes in Networks

Abstract: This paper considers the problem of identifying sets of structurally important nodes in a network. A number of related issues are considered. First, I outline the different reasons why we might want to identify key nodes, showing that different measures (known as centrality measures in the social network literature) are needed for each. Second, I show

how structural importance is affected by the manner in which things flow through a network. A typology is constructed to classify types of flows in terms of the kinds of trajectories that are possible (e.g., paths, trails or walks) and whether transmission occurs via serial replication, parallel replication or transfer. The relative importance of nodes in a given graph changes depending on what kind of flow process is operating. Third, I consider the problem of measuring the importance of sets of nodes. Finally, the subtext of the paper is a commentary on the nature of centrality measures and what they are intended to measure.

11:50	**Discussion**	
12:00	**Mark E. J. Newman** University of Michigan	How the Structure of Contact Networks Affects Disease Propagation

Abstract: I will discuss observational results on the statistical properties of contact networks, including degree distributions, correlation properties, transitivity, and assortativity. I will also discuss models of disease propagation on networks that have these properties and describe how the properties in question affect the spread of the disease. Some results are already well known, such as the fact that highly degree-assortative networks support epidemics at lower density, but others are not, such as the fact that high levels of transitivity cause diseases to saturate populations in regimes only slightly above the epidemic threshold.

1:30	**Mark E. J. Newman** University of Michigan	How the Structure of Contact Networks Affects Disease Propagation

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2:20	**Discussion**	
2:30	**Coffee Break**	Reception Room EE/CS 3-176
3:00	**Second Chances**	Speakers of the day respond to further questions, suggestions, re-frame their main points, look toward future directions.
3:30	**Concluding Remarks by Organizers**	
3:40	**End of Workshop**	

Monday, November 24

The 10:30 IMA break will be in Lind Hall 400.

Tuesday, November 25

The 10:30 IMA break will be in Lind Hall 400.

IMA POSTDOC SEMINAR, Lind Hall 409:

11:15-12:15	**Karen Ball** IMA	Factors of Processes on Groups and Graphs

Abstract: Let X be a set with a group G acting on it. We will consider the question of when there exists a G-homomorphism between two i.i.d. processes which are indexed by X. In the case where $X = G$, we will see that amenable and nonamenable groups are characterized by very different behavior with respect to this question. We will also consider the case where X is a graph. The proofs involve applications of interesting ideas from percolation theory.

The IMA Postdoc Seminar is organized by
Antar Bandyopadhyay and Balaji Gopalakrishnan.

12:45-2:15 pm	**Random Matrices** G. Anderson and O. Zeitouni	This course (Math 8660) meets in Physics 133

Wednesday, November 26

The 10:30 IMA break will be in Lind Hall 400.

BROWN BAG SEMINAR, Lind Hall 409:

12:00	**Antar Bandyopadhyay** IMA	Frozen Percolation Process: What Are Known and What Are Not Known

Abstract: See http://www.ima.umn.edu/for abstract

The IMA Brown Bag Seminar is organized by
Tim Garoni and Tamon Stephen.

Thursday, November 27

Thanksgiving, a University of Minnesota holiday. IMA offices will be closed.

Friday, November 28

A University of Minnesota floating holiday. IMA offices will be closed.

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PART III: CURRENT IMA PARTICIPANTS

FIRST YEAR POSTDOCTORAL MEMBERS

NAME	PREVIOUS INSTITUTION
Gerard Awanou	University of Georgia
Karen Ball	Indiana University
Antar Bandyopadhyay	UC Berkeley
Tim Garoni	University of Melbourne
Chuan-Hsiang Han	North Carolina State University
Lea Popovic	UC Berkeley

SECOND YEAR POSTDOCTORAL MEMBERS

NAME	PREVIOUS INSTITUTION
Olga Brezhneva	Russian Academy of Sci.
Lisa Evans	Georgia Tech
Balaji Gopalakrishnan	Georgia Tech
Herve Kerivin	University Blaise Pascal-France
Tamon Stephen	University of Michigan
Jing Wang	University of Minnesota

POSTDOCTORAL MEMBERS IN INDUSTRIAL MATHEMATICS

NAME	PREVIOUS INSTITUTION	INDUSTRIAL AFFILIATION
Yusuf Altundas	University of Pittsburgh	Schlumberger
Lili Ju	Iowa State University	VA Hospital
Haewon Nam	Texas A & M University	GE
Jun Zhao	Texas A & M University	Schlumberger

LONG TERM VISITORS

NAME	HOME INSTITUTION
Soohan Ahn	Seoul National University (SRCCS)
Yusuf Bilgin Altundas	University of Minnesota
Greg Anderson	University of Minnesota
Gerard Awanou	University of Minnesota
Karen Ball	University of Minnesota
Antar Bandyopadhyay	University of Minnesota
Maury Bramson	University of Minnesota
Olga Brezhneva	University of Minnesota
Laura Chihara	Carleton College
Shmuel Friedland	University of Illinois - Chicago
Tim Garoni	University of Minnesota
Balaji Gopalakrishnan	University of Minnesota
Chuan-Hsiang Han	University of Minnesota
Mark Handcock	University of Washington
David R. Hunter	Pennsylvania State University
Naresh Jain	University of Minnesota
Lili Ju	University of Minnesota
Christina Kendziorski	University of Wisconsin - Madison
Herve Kerivin	University of Minnesota
Mohammad Kazim Khan	Kent State University
Dohyun Kim	Seoul National University (SRCCS)
Thomas G. Kurtz	University of Wisconsin - Madison
Richard P. McGehee	University of Minnesota
Martina Morris	University of Washington
Haewon Nam	University of Minnesota
Michael Newton	University of Wisconsin - Madison
Amir Niknejad	University of Illinois - Chicago
Lea Popovic	University of Minnesota
Greg Rempala	University of Louisville
Arnd Scheel	University of Minnesota
Tamon Stephen	University of Minnesota
Simon Tavare	University of Southern California
Jing Wang	University of Minnesota
Stephen J. Willson	Iowa State University
Yuhong Yang	Iowa State University
Ofer Zeitouni	University of Minnesota
Jun Zhao	University of Minnesota

VISITORS IN RESIDENCE (as of 27 October 2003)

Samson Abramsky	Oxford U Computing Lab	11/01/03 – 11/06/03
Massoud Amin	U of Minnesota	11/02/03 – 11/06/03
Sevgi O. Aral	CDC	11/16/03 – 11/21/03
Alexis Arias	Icosystem Corporation	11/02/03 – 11/06/03
Bertran Auvert	Universite Paris V	11/16/03 – 11/21/03
Chris Barrett	Los Alamos	11/02/03 – 11/06/03
Daniel Barth-Jones	Wayne State	11/16/03 – 11/21/03
David Francis Batten	CSIRO	11/01/03 – 11/06/03
Ajay S. Behl	U of Minnesota	11/16/03 – 11/21/03
David Bell	Affiliated Systems, Inc.	11/15/03 – 11/21/03
Julian E. Besag	U of Washington	11/16/03 – 11/21/03
Marie-Claude Boily	Universite Laval	11/16/03 – 11/21/03
Stephen P. Borgatti	Boston College	11/18/03 – 11/22/03

Stephen Buckley	Watson Research Center	11/02/03 – 11/06/03
Carter Butts	U of California - Irvine	11/15/03 – 11/21/03
Kathleen Carley	Carnegie Mellon	11/16/03 – 11/21/03
James B. Carson	RisQuant Energy	11/03/03 – 11/06/03
Filippo Castiglione	IAC	11/01/03 – 11/07/03
Mani Chandy	Caltech	11/02/03 – 11/06/03
Bill Chen	Nankai U	11/02/03 – 11/04/03
Francesca Chiaromonte	Pennsylvania State U	11/16/03 – 11/23/03
Andrew Cleary	Lawrence Livermore	11/02/03 – 11/06/03
Benoit Couet	Schlumberger-Doll Research	11/03/03 – 11/05/03
Jane Cullum	Los Alamos	11/02/03 – 11/06/03
Amy Davidow	UMDNJ-New Jersey Medical School	11/16/03 – 11/21/03
Catherine Dibble	U of Maryland	11/02/03 – 11/07/03
Rodney Dyer	Iowa State U	11/15/03 – 11/22/03
Ken Eames	U of Cambridge	11/16/03 – 11/21/03
Martin Eichner	Eberhard Karl U Tubingen	11/16/03 – 11/23/03
Stephen Eubank	Los Alamos	11/02/03 – 11/06/03
Richard Falk	Rutgers	11/22/03 – 11/25/03
Marc W. Feldman	Stanford U	11/17/03 – 11/21/03
Simon Frost	U of California - San Diego	11/16/03 – 11/22/03
Richard M. Fujimoto	Georgia Inst. of Technology	11/03/03 – 11/05/03
Maria Gini	U of Minnesota	11/03/03 – 11/06/03
Steve Goodreau	U of Washington	11/16/03 – 11/21/03
Priscilla E. Greenwood	Arizona State U	11/16/03 – 11/21/03
Deven Hamilton	U of Washington - Seattle	11/16/03 – 11/20/03
Steve Harp	Adventium Labs	11/03/03 – 11/06/03
Dirk Helbing	Dresden U of Technology	11/01/03 – 11/06/03
Peter Hoff	U of Washington	11/16/03 – 11/21/03
Tad Hogg	Hewlett-Packard Company	11/02/03 – 11/06/03
Don R. Hush	Los Alamos	11/02/03 – 11/06/03
Mac Hyman	Los Alamos	11/02/03 – 11/06/03
Marija D. Ilic	Carnegie Mellon	11/03/03 – 11/05/03
Valerie Isham	U College - London	11/15/03 – 11/21/03
Gabriel Istrate	Los Alamos	11/02/03 – 11/06/03
Neil F Johnson	Oxford U	11/02/03 – 11/06/03
Ann Jolly	U of Manitoba	11/16/03 – 11/21/03
James H. Jones	U of Washington	11/16/03 – 11/21/03
Jaewook Joo	Rutgers, State U of New Jersey	11/16/03 – 11/21/03
Jeffrey O. Kephart	Watson Research Center	11/02/03 – 11/06/03
Wolfgang Ketter	U of Minnesota	11/03/03 – 11/06/03
Eun Heui Kim	California State U	11/16/03 – 11/22/03
Alden Klovdahl	Australian National U	11/16/03 – 11/24/03
Deddy Koesrindartoto	Iowa State U	11/02/03 – 11/04/03
Natalia Komarova	IAS	11/02/03 – 11/09/03
Adam Landsberg	Claremont Colleges	11/02/03 – 11/06/03
Reinhard Laubenbacher	Virginia Polytechnic	11/01/03 – 11/06/03
John Lavery	Army Research Office	11/03/03 – 11/04/03
Kristian Lindgren	Chalmers/Goteborg U	11/01/03 – 11/06/03
Francesco Xavier Llora	Urbana-Champaign	11/01/03 – 11/06/03
Priscilla S. Macansantos	U Philippines Baguio	11/16/03 – 11/22/03
Florencia Machin	U of Minnesota	11/03/03 – 11/06/03
Madhav Marathe	Los Alamos	11/02/03 – 11/06/03
Madhav Marathe	Los Alamos	11/16/03 – 11/21/03
Anders Martin-Lof	Stockholm U	11/16/03 – 11/21/03
Sheila McCarthy	U of British Columbia	11/16/03 – 11/21/03
Denis Mollison	Heriot-Watt U	11/15/03 – 11/21/03

James Moody	Ohio State U	11/15/03 – 11/21/03
Henning Mortveit	Los Alamos	11/02/03 – 11/06/03
Akira Namatame	National Defense Academy	11/02/03 – 11/06/03
Claudia Neuhauser	U of Minnesota	11/16/03 – 11/21/03
Mark Newman	U of Michigan	11/19/03 – 11/22/03
David A. Ostrowski	Ford Motor Company	11/02/03 – 11/06/03
Bodo Pareigis	Universitat Munchen	11/01/03 – 11/06/03
Arjendu K. Pattanayak	Carleton College	11/17/03 – 11/21/03
Phillipa Pattison	U of Melbourne	11/16/03 – 11/21/03
Stephanie M. Potoka	Parker Hughes Cancer Inst.	11/03/03 – 11/06/03
Christian M. Reidys	Los Alamos	11/02/03 – 11/06/03
Valencia Remple	U of British Columbia	11/16/03 – 11/22/03
Garry Robins	U of Melbourne	11/16/03 – 11/21/03
Richard B. Rothenberg	Emory U	11/16/03 – 11/21/03
Matthew Salganik	Columbia U	11/16/03 – 11/21/03
Anne Schneeberger	Imperial College, London	11/16/03 – 11/21/03
Timothy Schoenharl	Notre Dame U	11/02/03 – 11/05/03
Peter Schuster	Inst. Theoretische Chemie&Molek.	10/31/03 – 11/05/03
Markus Schwehm	U of Tuebingen	11/16/03 – 11/23/03
Carl Simon	U of Michigan	11/16/03 – 11/21/03
Tom Snijders	U of Groningen	11/12/03 – 11/22/03
Peter F. Stadler	Universitat Leipzig	11/02/03 – 11/06/03
Martha Steenstrup	Stow Research L.L.C.	11/01/03 – 11/05/03
Bernd Sturmfels	U of California - Berkeley	11/02/03 – 11/06/03
Jeremy Tantrum	U of Washington	11/03/03 – 11/07/03
Jeremy Tantrum	U of Washington	11/16/03 – 11/21/03
Richard Tapia	Rice U	11/20/03 – 11/21/03
Leigh Tesfatsion	Iowa State U	11/02/03 – 11/07/03
Steven K. Thompson	Pennsylvania State U	11/16/03 – 11/21/03
Zolton Toroczkai	Los Alamos	11/02/03 – 11/06/03
Robert T. II Trotter	Northern Arizona U	11/16/03 – 11/21/03
Anil Vullikanti	Los Alamos	11/16/03 – 11/21/03
Tom Wagner	Honeywell	11/03/03 – 11/06/03
Nan Wang	U of Maryland	11/16/03 – 11/21/03
Chirstopher Warren	U of Michigan	11/16/03 – 11/21/03
Stanley Wasserman	Urbana-Champaign	11/16/03 – 11/21/03
Duncan Watts	Columbia U	11/16/03 – 11/21/03
Howard Weiss	Pennsylvania State U	11/01/03 – 11/05/03
Ragnar Winther	Universitetet of Oslo	11/22/03 – 11/25/03
David H. Wolpert	NASA Ames Research Center	11/02/03 – 11/06/03
Zhiwei Zhang	U of Chicago	11/16/03 – 11/21/03

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