INSTITUTE FOR MATHEMATICS AND ITS APPLICATIONS

University of Minnesota
400 Lind Hall
207 Church Street S.E.
Minneapolis, Minnesota 55455
FAX (612) 626-7370 telephone (612) 624-6066 e-mail: ima-staff@ima.umn.edu
IMA Schedules via finger: finger seminar@ima.umn.edu
Newsletters, Updates and preprints are available via
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The IMA was founded by and receives major support from the National Science Foundation.

IMA NEWSLETTER # 328

1–29 February 2004

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

IMA Tutorial:

Robustness and the Internet: Design, Evolution, and Theoretical Foundations

8 February 2004
Speakers: Walter Willinger (AT&T Labs - Research), John Doyle (California Institute of Technology),

See http://www.ima.umn.edu/complex/winter/t3.html

IMA Workshop:

Robustness in Complex Systems

9–13 February 2004
Organizers: Walter Willinger (AT&T Labs - Research), John Doyle (California Institute of Technology),

See http://www.ima.umn.edu/complex/winter/c5.html

PARTICIPATING INSTITUTIONS: Consiglio Nazionale delle Ricerche (CNR), 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: ExxonMobil, Ford, General Electric Company, General Motors, Honeywell, IBM, Lockheed Martin, Lucent, Motorola, Schlumberger, Siemens, Telcordia Technologies, 3M.

Version of March 4, 2004

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 1–29 FEBRUARY 2004

Monday, February 2

The 3:00 IMA break will be in Lind Hall 400.

Tuesday, February 3

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

IMA POSTDOC SEMINAR, Lind Hall 409:

11:15–12:15 **Greg Rempala**
University of Louisville
Bootstrapping Parametric Models of Mortality

Abstract: We consider a general problem of modeling a mortality law of a population of failing units with some parametric function. In this setting we define a mortality table of crude rates as a statistical estimator with multinomial distribution and show its consistency as well as asymptotic normality. We further derive the statistical properties of parameter estimators in a parametric mortality model based on a weighted square loss function. We use the obtained results to study consistency and appropriateness of the parametric bootstrap method in our setting. We derive the conditions on the assumed parametric mortality law and the loss function, under which the bootstrap is consistent for estimating the model parameters, their standard errors and corresponding confidence intervals. We apply our results to a model of Aggregate US Mortality Table based on a so called mixture of extreme value distributions suggested by Carriere (1992).

The IMA Postdoc Seminar is organized by
Antar Bandyopadhyay and Gerard Awanou.

Wednesday, February 4

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

BROWN BAG SEMINAR, Lind Hall 409:

12:00 **Shmuel Friedland**
University of Illinois - Chicago / IMA
Singular Value Decomposition in Inner Product Spaces with Applications to DNA Microarrays

Abstract: Singular Value Decomposition (SVD) is a very useful and versatile tool in pure and applied mathematics. Usually one considers an $N \times M$ real valued matrix A as a linear operator from $\mathbb{R}^M \to \mathbb{R}^N$, where $\mathbb{R}^M$ and $\mathbb{R}^N$ are endowed with the standard inner products. In this talk we consider the SVD of A when $\mathbb{R}^M$ and $\mathbb{R}^N$ endowed with arbitrary inner products. This case has a natural interpretation in Principal Component Analysis when one considers correlated random variables.

We show that the singular value decomposition with respect to a certain inner product in $\mathbb{R}^M$ gives the generalized singular value decomposition for two matrices with M columns and different sizes of rows, introduced recently to compare two sets of DNA microarrays of different organisms.

S. Friedland, Singular Value Decomposition in DNA Microarrays,

http://www.ima.umn.edu/preprints/jan2004/jan2004.html

Thursday, February 5

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

COMPLEX SYSTEMS SEMINAR, Lind Hall 409:

1:30 pm	**Wanyang Dai** Nanjing University	On the Existence and Non-Sample Estimation of Stationary Densities of Semimartingale Reflecting Brownian Motions

Abstract: We will present algorithms to estimate the stationary densities of semimaringale reflecting Brownian motions (SRBMs) which have been demonstrated as diffusion approximation models in performance predictions and evaluations for numerous complex queueing networks. Our estimation algorithms are considered as non-sample nonparametric inference method since they do not depend on any observed sample data. When the state space for the SRBMs is a d-dimensional hypercube, we develop an approach to establish the weak convergence in certain sense for a slightly refined finite element estimator from our previous implemented algorithm (currently, complete convergence analysis is an open issue for all of existing estimators in this area). The modification is slight since it only has minor influence to the original algorithm in determining the entry values of some associated coefficient matrix by re-selecting basis functions and properly organizing them, however, the condition number for the matrix is reduced and hence the numerical stability is improved. When the state space is the d-dimensional positive orthant, we design an adaptive finite element estimator in certain sense to compute the stationary distribution and extend the developed weak convergence analysis approach to form a constructive method to establish the existence of a stationary distribution for an SRBM living in the orthant. Combining our finding with some existing achievement, the uniqueness of the stationary distribution for the SRBM is also established. All of the discussions are under a completely-S condition which is as general as the one to guarantee the existence (in distribution) of an SRBM and under a general Borel integrable condition for the stationary density of the SRBM.

Friday, February 6

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

Sunday, February 8

IMA Tutorial:

Robustness and the Internet: Design, Evolution, and Theoretical Foundations

8 February 2004

Speakers: Walter Willinger (AT&T Labs - Research), John Doyle (California Institute of Technology),

See http://www.ima.umn.edu/complex/winter/t3.html

This tutorial uses the Internet as starting point for a scientific exploration of the broader issues of robustness in complex systems throughout technology and biology. In most of these systems, complexity is driven by the need for robustness

to uncertainty in their environments and components far more than by basic functionality. At the same time, most of this complexity tends to be hidden, deliberately creating the illusion of superficially simple systems, which has encouraged the development of specious theories.

The objective of this tutorial is to outline an emerging theoretical foundation for the Internet that provides a sound framework for understanding both success and shortcomings of existing Internet technologies, offers alternative protocols for identified problems, guides the rational design for future evolution of ubiquitous networking, and suggests what new mathematics and technology will be needed for developing a useful, general theory of complex systems.

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

9:00–10:00	**John C. Doyle** California Institute of Technology	Networking 101 for Biologists: Internet Design and Evolution I
10:30–11:30	**John C. Doyle** California Institute of Technology	Biology 101 for Networking Researcher: The Biological Internet II
1:30–2:30	**Stephen Prajna** California Institute of Technology	Robustness in Complex Systems: Theoretical Foundations I
3:00–4:00	**Antonis Papachristodoulou** California Institute of Technology	Robustness in Complex Systems: Theoretical Foundations II

Ordinary or Functional differential equations with uncertain parameters can be used to model a variety of systems. Analysis usually proceeds by further simplification to the investigation of the linearizations of these models, or a series of assumptions that result in conservativeness or may be misleading. This methodology offers scalability, but the conclusions are only locally correct. Investigating the properties of the system at the nonlinear level with delays is usually cumbersome. Using the Sum of Squares decomposition, we will build a framework for the algorithmic analysis of nonlinear ordinary and functional differential equations, taking examples from network congestion control.

Monday, February 9

IMA Workshop:

Robustness in Complex Systems

9–13 February 2004

Organizers: Walter Willinger (AT&T Labs - Research), John Doyle (California Institute of Technology),

See http://www.ima.umn.edu/complex/winter/c5.html

Recent research efforts have provided for the first time a nascent but promising foundation for a rigorous, coherent, and reasonably complete mathematical theory underpinning Internet technology. This new theory addresses directly the performance and robustness of both the "horizontal" decentralized and asynchronous nature of control in TCP/IP as well as the "vertical" separation into the layers of the TCP/IP protocol stack from application down to the link layer. The new findings generalize notions of source and channel coding from information theory as well as decentralized versions of robust control. In addition, the resulting new theoretical insights about the Internet also combine with our understanding of its origins and evolution to provide a rich source of ideas about complex systems in general. Most surprisingly, our deepening understanding from genomics and molecular biology has revealed that at the network and protocol level, cells and organisms are strikingly similar to technological networks, despite having completely different material substrates, evolution, and development/construction.

This workshop will bring together Internet researchers, scientists working on a range of different technological networks, biologists and biophysicists, mathematicians, and computer scientists. It will provide for a unique opportunity for engineers and biologists to compare notes and share insights from engineering theory and practice that can shed new light on biological complexity or from biology that can illuminate existing mysteries associated with the complexity of large-scale engineered networks.

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	**Adam P. Arkin** Lawrence Berkeley National Laboratory	Playing Practical Games with Bacteria and Viruses. Exploring the Molecular Mechanisms Behind Clever Cellular Stratagems

Abstract: How do pathogenic bacteria sense their environment to deploy different survival strategies? Why do some viruses, like HIV, allow their host to live for long periods whereas others like Ebola do not? How precisely are these strategies encoded in the organism's biochemistry and genetics and how closely do they need to be followed to guarantee its survival? What are the optimal strategies for defeating these organisms or forcing them to do our bidding for industrial or medical benefit? Here I will demonstrate, using examples from our research on Bacillus subtilis stress response and the design of HIV gene therapeutic strategies, how molecular biology combined with methods from statistical physics, nonlinear dynamics, and game theory can be used to pose and partially answer these questions as well as illustrate some of the profound challenges in doing so.

10:20	**Discussion**	
10:30	**Coffee Break**	Reception Room EE/CS 3-176
11:00	**Steven Low** California Institute of Technology	Utility Maximization, Routing, and Fair-Efficiency Tradeoff

Abstract: It turns out that TCP-AQM can be interpreted as a distributed primal-dual algorithm over the Internet to maximize aggregate utility over source rates. Indeed an allocation policy can be defined in terms of a class of utility functions characterized by a scalar parameter alpha. A allocation is fair if alpha is large, and efficient if the aggregate source rate is large. All examples in the literature suggest that a fair allocation is necessarily inefficient. We characterize exactly the tradeoff between fairness and throughput in general networks. The characterization allows us both to produce the first counter-example and trivially explain all the previous supporting examples. Surprisingly, the class of networks in our counter-example is such that a fairer allocation is always more efficient.

Will TCP-AQM/IP maximize aggregate utility over both source rates and routes? We show that the problem is NP-hard and therefore cannot be solved by minimum cost routing in general. We exhibit inevitable tradeoff between routing stability and achievable utility.

(Joint work with J. Doyle, L. Li, A. Tang, J. Wang).

11:50	**Discussion**	
12:00	**Lunch Break**	

1:30	**John C. Doyle** California Institute of Technology	Title TBA
2:20	**Discussion**	
2:30	**Coffee Break**	Reception Room EE/CS 3-176
3:00	**Second Chances** Moderator: Walter Willinger	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

Tuesday, February 10

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

9:00	**Coffee**	Reception Room EE/CS 3-176
9:30	**Francis J. Doyle III** University of California, Santa Barbara	Robustness Analysis of Gene Regulatory Network Underlying Circadian Rhythms

Abstract: The gene network which underlies circadian rhythms is an ideal system for robustness studies, owing to its remarkable performance in a highly uncertain environment. Of interest for control theoretic analyses, the dominant elements of the postulated architecture for Drosophila consist of nested negative autoregulatory feedback loops controlling the expression of timeless (tim) and period (per) interlocked with a positive feedback loop established via the dClock gene. Complex formation, regulated translocation and degradation of several of these gene products, which is additionally controlled (and delayed) by protein phosphorylation, add further levels of complexity to the system. Ongoing efforts to model and analyze this system using formal systems engineering methods will be presented.

10:20	**Discussion**	
10:30	**Coffee Break**	Reception Room EE/CS 3-176
11:00	**Lixia Zhang** University of California, Los Angeles	Large Scale, Complexity, and Robustness–a Pragmatic View
11:50	**Discussion**	
12:00	**Lunch Break**	

1:30	**David Alderson** Caltech	The Role of Design in the Internet and Other Complex Systems

Abstract: The Internet offers an attractive case study of a complex network, since our understanding of the underlying technology together with the ability to perform detailed measurements means that most conjectures about its large-scale properties can be unambiguously resolved, though often not without substantial effort. A fundamental challenge in the study of the Internet and other complex systems is to identify and understand the relationship between large-scale features and their underlying mechanisms. One popular approach leverages the tools of statistical physics to emphasize emergent properties of random ensembles, typically with constraints on macroscopic statistics. The main focus is on generic configurations whose construction is governed by randomness and are likely to occur by chance. A recent example of this perspective when applied to the Internet are the so called "scale-free" models of network connectivity graphs. These models claim that the emergence of power laws in the distribution of node degrees in these graphs is essentially explained by a random process that involves preferential attachment and reveals what has become known as the "Achilles' heel of the Internet"–the presence of a few highly connected hubs within the core of the network that, when disabled by targeted attacks, will bring the Internet to its knee. An alternative perspective, motivated by engineering, suggests that nonrandom design rather than randomness plays a primary role in the construction and evolution of complex systems. The emphasis here is on non-generic, highly engineered configurations that are extremely unlikely to occur by chance, and the complex structure of highly engineered technology and of biological systems is viewed as the natural by-product of tradeoffs between system-specific objectives and constraints.

This talk shows how and why the latter view, when applied to the study of router-level Internet connectivity, results in conclusions that are fully consistent with the real Internet, but are the exact opposite of what the scale-free models claim. The reasons for reaching such divergent conclusions about one and the same system go well beyond the Internet and scale-free models and are endemic in the application of ideas from statistical physics to problems in technology and biology, where it is assumed that the details related to a complex system's design, functionality, constraints, and evolution (i.e., all ingredients that make engineering and biology different from physics) can be safely ignored in favor of random ensembles and their emergent properties.

(This represents joint work with J. Doyle, W. Willinger, and L. Li.)

2:20	**Discussion**	
2:30	**Coffee Break**	Reception Room EE/CS 3-176
3:00	**Ramesh Johari** Massachusetts Institute of Technology	A Game Theoretic View of Efficiency Loss in Network Resource Allocation

Abstract: The Internet has evolved into a heterogeneous system, comprised of many users who value their own performance, rather than the efficiency of the system as a whole; as a result, proposals for network resource allocation must be robust against self-interested behavior of the network users. With this motivation, we analyze a network congestion game in which the users of congested finite-capacity links anticipate the effect of their actions on the link prices. We show existence of a Nash equilibrium, discuss uniqueness, and establish that the efficiency of the system drops by no more than 25% relative to the social optimum. We also consider an extension of this model to links with elastic capacity; we again establish existence of a Nash equilibrium, and show that in this case the efficiency of the system drops by no more than $6 - 4\sqrt{2}$ (approximately 34%) relative to the social optimum. Finally, we discuss some implications of these results for current work on Internet congestion control.

This is joint work with John Tsitsiklis and Shie Mannor.

3:50	**Discussion**	
4:00	**Coffee Break**	Reception Room EE/CS 3-176

4:30	**Second Chances** Moderator: Thomas G. Kurtz	Speakers of the day respond to further questions, suggestions, re-frame their main points, look toward future directions.

Wednesday, February 11

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

9:00	**Coffee**	Reception Room EE/CS 3-176
9:30	**Massoud Amin** University of Minnesota	Robustness and Resilience of Critical Infrastructures

Abstract: The massive August 14, 2003 power outage in the United States and Canada evoked eerie reminders of what shook our world on September 11, 2001. While early reports indicated no apparent evidence of terrorism in this outage or those in the UK and Italy in 2003, the cascading blackouts spotlighted our electricity infrastructure's vulnerabilities. This infrastructure affects us all – are we prepared for future storms?

Our economy and security places increased demand for reliable, disturbance-free electricity. Virtually every crucial economic and social function depends on the secure, reliable operation of energy, telecommunications, transportation, financial, and other infrastructures. The Internet, computer networks, and our digital economy have increased the demand for reliable and disturbance-free electricity; banking and finance depends on the robustness of electric power, cable, and wireless telecommunications. Transportation systems, including military and commercial aircraft and land and sea vessels, depend on communication and energy networks. Links between the power grid and telecommunications and between electrical power and oil, water, and gas pipelines continue to be a lynchpin of energy supply networks.

The potential ramifications of network failures have never been greater, as the transportation, telecommunications, oil and gas, banking and finance, and other infrastructures depend on the continental power grid to energize and control their operations. Furthermore, as the power grids become heavily loaded with long distance transfers, the already complex system dynamics become even more important. The potential for rare-events but high-impact cascading phenomena represent just a few of many new science and technology concepts that are under development.

This presentation focuses on robustness and resilience of critical infrastructures, in particular focusing on electricity infrastructure combined with economic and communication layers. We briefly present the overall context in which these coupled infrastructures are operated in, followed by challenges associated with achieving increased situational awareness of operators/security monitors, signals and precursors to failures, infrastructure defense plans, protection against rare events and extreme contingencies, along with rapid/robust restoration.

¿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. 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.

10:20	**Discussion**	
10:30	**Coffee Break**	Reception Room EE/CS 3-176
11:00	**Andrew T. Ogielski** Renesys Corporation	Impact of the 2003 Blackouts on Internet Communications

Abstract: In August 2003, electric power outages affected 50 million people in the Northeastern US and Canada, causing economic losses estimated to exceed $5 billion. The outage was not only the largest in US history, but also the first of its scale since the rise of the commercial Internet and the World Wide Web.

In this report we examine the impact the blackout had on Internet connectivity and traffic routing in the region, as recorded in real time in data collected from Internet routers worldwide. We find that Internet connectivity in the blacked-out region was far more seriously affected than has been publicly revealed.

While the very largest provider networks (the Internet backbones) were apparently unaffected by the blackout [KN1, KN2], many thousands of significant networks and millions of individual Internet users were offline for hours or days. Banks, investment funds, business services, manufacturers, hospitals, educational institutions, internet service providers, and federal and state government units were among the affected organizations.

In this presentation we describe the time course and statistics of various network outage metrics during the US/Canadian blackout (August 14–16, 2003). We also provide a comparative analysis of Internet outages during a country-wide blackout in Italy on September 28, 2003 that reveals some interesting statistical similarities despite significant differences in Italian Internet architecture. These similarities may indicate the existence of more general statistical laws describing the expected number of connectivity failures and their time courses under wide-area network failures due to blackouts or other disasters. This is a suggested subject for future research.

The report is available on the Web at http://www.renesys.com/news/index.html.

11:50	**Discussion**	
12:00	**Lunch Break**	
1:30	**Carla P. Gomes** Cornell University	Heavy-Tailed Phenomena in Computation

Abstract: We study the run time profiles of combinatorial search methods. Our study reveals that such methods have a large variability in performance. In fact the runtime distributions of combinatorial search methods exhibit intriguing properties, often characterized by very long tails or "heavy tails." Such non-standard distributions have recently been observed in areas as diverse as economics, statistical physics, and geophysics. We discuss how one can boost the performance of search procedures by exploiting the heavy tail phenomena. We demonstrate speedups of several orders of magnitude for state-of-the-art complete search procedures running on real-world problem instances. We also discuss formal models of heavy-tails in combinatorial search and discuss different "statistical regimes of heavy-tailed behavior" in combinatorial domains, providing a general characterization of parameter regions where heavy-tailed behavior is prevalent.

2:20	**Discussion**	
2:30	**Coffee Break**	Reception Room EE/CS 3-176
3:00	**Stephen Prajna** California Institute of Technology	Relating Robustness and Complexity

Abstract: Biologists and engineers often find the task of verifying the functionality of their systems onerous. They are many times obligated to modify their ambitious inquiries, either because these inquiries are not well-posed, or because they are computationally prohibitive. Modifying the inquiries to render them simpler yet more meaningful and robust is an important aspect of this process, as it is more likely that the resulting questions will have easier answers with shorter proofs, and small perturbations will not nullify the answers. When the questions have been carefully posed to avoid the above complication, the difficulty in answering them has a profound albeit not well understood relationship to the system robustness. The computational effort required in functionality verification is deeply connected to hidden fragilities which may lead to system failure, and this computational complexity indicates a bound on the maximum possible robustness. We will advocate and illustrate these issues using the Number Partitioning Problem, a deceptively "simple" problem which in fact is NP-hard.

3:50	**Discussion**	
4:00	**Coffee Break**	Reception Room EE/CS 3-176
4:30	**Second Chances** Moderator: John Byers	Speakers of the day respond to further questions, suggestions, re-frame their main points, look toward future directions.

Thursday, February 12

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

9:00	**Coffee**	Reception Room EE/CS 3-176
9:30	**Michael A. Savageau** University of California, Davis	Robustness and Evolvability of Gene Circuitry

Abstract: Robustness is observed at many different levels in biological systems. By robustness I mean that the system tends to continue performing its function despite changes in the parameters that define the relatively fixed nature of the system. Three explanations of this robustness have been commonly proposed. First, that there are redundant back-up mechanisms that take over the function when the original mechanism is compromised, much like the spare tire in the trunk of your car. Second, that robustness is a mathematical necessity, which is the result of the underlying mathematical model that governs biological systems. Third, that network topology produces robustness as a result of numerous alternative routes that provide connectivity between the components of the network. Each of these explanations implies that robustness is basically a gratuitous property and that function and design by natural selection have little if any role to play. I will suggest two additional explanations for the robustness of biological systems - thermodynamics and regulation – in which consideration of function and design by natural selection play a prominent role. I also will examine the robustness of alternative biological designs, which provides the context for a comparison of these explanations. These results demonstrate that system robustness is an important criterion for, and consequence of, design by natural selection.

10:20	**Discussion**	
10:30	**Coffee Break**	Reception Room EE/CS 3-176
11:00	**Craig Partridge** BBN Technologies	Frequency Analysis of Protocols

Abstract: In the past three years or so, a few different researchers have begun to use frequency analysis to try to understand features of data networks and their protocols. Their use of frequency techniques has varied widely, and in some cases, we've got evidence that frequency techniques work (in surprising ways) without a strong understanding of why they work.

In this talk I try to survey the work that has been done to date, talk about apparent strengths and weaknesses of the various pieces of work, and talk about the interesting open questions that I believe this work raises.

11:50	**Discussion**	
12:00	**Lunch Break**	

1:30	**Venkat N. Padmanabhan** Microsoft Research	Impact of Interference on Multi-hop Wireless Network Performance

Abstract: Multi-hop wireless networks are growing in importance, driven by applications such as community networking and sensor networking. A key characteristic of such networks is that the (wireless) links are not independent — the operation of one link may interfere with the operation of other links in its vicinity. This raises interesting and fundamental questions of what the throughput capacity of such networks is and how it is impacted by network scale and engineering parameters such as radio range, number of channels, etc.

We survey prior work in this area, including the seminal work of Gupta and Kumar, that has focused on computing asymptotic capacity bounds under assumptions of homogeneity or randomness in the the network topology and/or workload. We then present our work which considers the throughput performance question for any given network and workload specified as inputs. The *conflict graph* framework we develop enables "what-if" analysis of the impact of various network parameters on throughput. We conclude by pointing out several avenues for future work.

(Joint work with K. Jain, J. Padhye, and L. Qiu).

2:20	**Discussion**	
2:30	**Coffee Break**	Reception Room EE/CS 3-176
3:00	**Second Chances** Moderator: Dina Katabi	Speakers of the day respond to further questions, suggestions, re-frame their main points, look toward future directions.
6:00	**Workshop Dinner**	Bangkok Thai, 425 13th Ave SE

Friday, February 13

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

9:00	**Coffee**	Reception Room EE/CS 3-176
9:30	**Mustafa Khammash** University of California at Santa Barbara	Modeling and Analysis of Bacterial Stress-Response

Abstract: The heat shock response in bacteria is an important mechanism for combating the stress associated with an increase in temperature in the cellular environment. The resulting increased heat causes the unfolding or misfolding of cellular proteins and leads to a state of cellular stress. The cell responds to the accumulation of nonfunctional proteins by the heat induced upregulation of the heat shock proteins (HSPs), including both chaperones and proteases. The production of HSPs is regulated directly by alterations in the level, activity, and stability of the sigma factor sigma-32. The logic of the heat shock response is implemented through a hierarchy of feedback and feedforward controls that regulate both the amount of sigma-32 and its functionality. In this talk we present a dynamic model that captures known aspects of the heat shock system. With the aid of this model, we discuss the logic of the heat shock response from a control theory perspective, drawing comparisons to synthetic engineering control systems. Questions related to stochastic modeling, robustness analysis, and model validation will also be discussed and related mathematical challenges will be outlined.

10:20	**Discussion**

10:30	**Coffee Break**	Reception Room EE/CS 3-176
11:00	**Antonis Papachristodoulou** Caltech	Analysis of nonlinear delay models for TCP/AQM

Abstract: Understanding the properties of complex systems such as the Internet requires the construction of robust models followed by an appropriate analysis. The models that are usually used are in the form of coupled nonlinear delay differential equations, but the absence of efficient methodologies for analysis at this model level often leads to the investigation of their linearizations or their un-delayed versions. In this presentation we will introduce an algorithmic procedure for the analysis of nonlinear TCP/AQM protocols modelled by functional differential equations using the Sum of Squares decomposition and convex optimization.

11:50	**Discussion**	
12:00	**Lunch Break**	
1:30	**Pablo A. Parrilo** Swiss Federal Institute of Technology	SOS Relaxations for System Analysis: Possibilities and Perspectives

Abstract: We present an overview of the theory and applications of sum of squares (SOS) relaxations in system and robustness analysis. The developed techniques, based on convex optimization and results from real algebraic geometry, unify and generalize many well-known existing methods, such as those based on the S-procedure. The ideas and algorithms will be illustrated through examples, emphasizing recent developments as well as future challenges.

2:20	**Discussion**	
2:30	**Coffee Break**	Reception Room EE/CS 3-176
3:00	**Second Chances** Moderator: John C. Doyle	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, February 16

The 3:00 IMA break will be in Lind Hall 400.

Tuesday, February 17

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

JOINT IMA POSTDOC/BROWN BAG SEMINAR, Lind Hall 409:

11:15-12:15 **Lili Ju** Finite Volume Method on Spherical Voronoi Meshes
IMA

Abstract: We first develop and analyze a finite volume scheme for the discretization of partial differential equations on the sphere; the scheme uses Voronoi tessellation of the sphere. For a model convection-diffusion problem, the finite volume scheme is shown to produce first-order accurate approximations with respect to a mesh-dependent discrete first-derivative norm. Then, we introduce the notion of constrained centroidal Voronoi tessellation (CCVTs) of the sphere; these are special Voronoi tessellation of the sphere for which the generators of the Voronoi cells are also the constrained centers of mass, with respect to a prescribed density function, of the cells. After discussing an algorithm for determining CCVT meshes on the sphere, we discuss and illustrate several desirable properties possessed by these meshes. In particular, it is shown that CCVT meshes define very high quality uniform and nonuniform meshes on the sphere. Finally, we discuss, through some computational experiments, the performance of the CCVT meshes used in conjunction with the finite volume scheme for the solution of simple model PDEs on the sphere. The experiments show, for example, that the CCVT based finite volume approximations are second-order accurate if errors are measured in discrete L^2-norms.

JOINT IMA POSTDOC/RANDOM MATRICES SEMINAR, Vincent Hall 570:

12:45–2:15 **Tim Garoni** Absolute Moments of Products of Characteristic Polynomials, and Impenetrable Bosons - I
IMA

Abstract: I will discuss the links between the moments of products of characteristic polynomials of random matrices, with the asymptotics of a certain class of Hankel determinants, and also with certain 1D quantum models. Some exact results from the literature will be discussed, as well as some interesting and as yet unproven conjectures.

The IMA Postdoc Seminar is organized by
Antar Bandyopadhyay and Gerard Awanou.

Wednesday, February 18

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

Thursday, February 19

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

COMPLEX SYSTEMS SEMINAR, Lind Hall 409:

1:30 pm **Zhi-Li Zhang** Understanding and Limiting BGP Instabilities
University of Minnesota

Abstract: Slow convergence in the Internet can be directly attributable to the path exploration phenomenon, inherent in all path vector protocols. The root cause for path exploration is the dependency among paths propagated through the network. Addressing this problem in BGP is particularly difficult as the AS Paths exchanged between BGP routers are highly summarized.

In the first part of this talk, we will describe why the path exploration cannot be countered effectively within the existing BGP framework, and propose a simple, novel mechanism – forward edge sequence number to annotate the AS Paths with additional information. With this mechanism, we develop an enhanced path vector algorithm, EPIC, which can be shown to limit path exploration and lead to faster convergence. In contrast to other solutions, EPIC is shown to be correct on a very general model of Internet topology and BGP operation. Using theoretical analysis and simulations, we demonstrate that EPIC can achieve a dramatic reduction in routing convergence time, as compared to BGP and other existing solutions.

In the second part of the talk, we will briefly discuss some of initial work on identifying locations and causes of BGP instabilities using observed BGP updates from one or multiple vantage points, and the difficulties we encountered. Perhaps more innovative or sophisticated approaches are necessary, and this is where we would like to obtain some help from mathematicians/statisticians.

Friday, February 20

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

IMA/MCIM INDUSTRIAL PROBLEM SEMINAR, 570 Vincent Hall:

1:25pm	**William Frey** General Motors R&D Center	Modeling Buckled Developable Surfaces for Binder Design in Sheet Metal Forming

Abstract: In the first stage of sheet metal stamping, a binder ring, an annular surface surrounding the die cavity, clamps down on the flat blank, bending it to a developable "binder wrap" surface which may be smooth or buckled. Buckles generally appear in the binder wrap when the binder ring does not lie on a smooth developable surface that spans the die cavity. However, sometimes buckles can improve the formability of the stamped part, so the ability to design buckled developable surfaces becomes desirable. Designing buckled developable surfaces requires geometric modeling of creases and other singularities in the interior of a flat sheet. In this talk, I will review the properties of such surfaces, describe a method of approximating buckled binder wrap surfaces by developable three-dimensional triangulations and discuss the insights gained from specific examples.

Monday, February 23

The 3:00 IMA break will be in Lind Hall 400.

Tuesday, February 24

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

JOINT IMA POSTDOC/RANDOM MATRICES SEMINAR, Vincent Hall 570:

12:45–2:15	**Tim Garoni** IMA	Absolute Moments of Products of Characteristic Polynomials, and Impenetrable Bosons - II

Abstract: I will discuss the links between the moments of products of characteristic polynomials of random matrices, with the asymptotics of a certain class of Hankel determinants, and also with certain 1D quantum models. Some exact results from the literature will be discussed, as well as some interesting and as yet unproven conjectures.

The IMA Postdoc Seminar is organized by
Antar Bandyopadhyay and Gerard Awanou.

Wednesday, February 25

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

BROWN BAG SEMINAR, Lind Hall 409:

12:00	**Julien Bremont** ENS	Maximizing Measures and Related Questions

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

Thursday, February 26

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

COMPLEX SYSTEMS SEMINAR, Lind Hall 409:

1:30 pm **Jacek Wesolowski** Conditional Moments of q-Meixner Processes
Warsaw Technical University

Abstract: A class of stochastic processes with linear conditional expectations and quadratic conditional variances will be described. It appears that they are Markov and their transition probabilities are related to a three-parameter family of orthogonal polynomials which generalize the Meixner polynomials. Special cases of these processes are known to arise from non-commutative generalizations of certain Levy processes.

Joint work with W. Bryc (Univ. of Cincinnati).

Friday, February 27

1:25pm **Darek Madej** Matching Wavelets to Signals. Speckle Noise Filtering in a Laser Bar Code Scanner
Symbol Technologies

Abstract: Speckle noise, which arises in coherent illumination of diffusing target, is a principal factor limiting performance of a laser bar code scanner and its miniaturization. Speckle noise cannot be eliminated using tradition signal processing methods, like Fourier domain filtering, averaging of several signals, or denoising by wavelet shrinkage.

The author will present a denoising method using a nonlinear filtering in a ”quasi” wavelet space. First, a signal is transformed by means of an integral transformation, which resembles Continuous Wavelet Transform (CWT). However, a family of wavelets for different scales is generated not by dilation, like it would have been in the CWT, but in another, systematic way. Proposed transformation, we call it QCWT (Quasi CWT), seems to be invertible, and each wavelet fulfills the wavelet admissibility condition. The advantage of such approach is that ”wavelets” match closely elements of bar code signals, which allows for better performance. Local maxima of the transformed signal are used for the denoising process. Additionally statistical properties inferred from signal are used to reduce the required computations.

The proposed method allows for decoding bar codes with signal-to-noise ratio lower by 10 dB, and is compared to other advanced methods used in laser scanners.

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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.
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
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)
Greg Anderson	University of Minnesota
Maury Bramson	University of Minnesota
Hi Jun Choe	Yonsei University
Wanyang Dai	Nanjing University
Shmuel Friedland	University of Illinois - Chicago
Naresh Jain	University of Minnesota
Mohammad Kazim Khan	Kent State University
Dohyun Kim	Seoul National University (SRCCS)
Hye-Ryoung Kim	Seoul National University (BK 21 Math-SNU)
Thomas G. Kurtz	University of Wisconsin
Richard P. McGehee	University of Minnesota
Amir Niknejad	University of Illinois - Chicago
Greg Rempala	University of Louisville
Arnd Scheel	University of Minnesota
Hui Wang	Brown University
Yuhong Yang	Iowa State University
Ofer Zeitouni	University of Minnesota

VISITORS IN RESIDENCE (as of 26 January 2004)

David Alderson	California Institute of Technology	2/08/04 – 2/13/04
Adam P. Arkin	Lawrence Berkeley National Laboratory	2/08/04 – 2/13/04
John Byers	Boston University	2/09/04 – 2/13/04
Changho Choi	University of Minnesota	2/09/04 – 2/13/04

Frank Doyle	University of California - Santa Barbara	2/08/04 – 2/13/04
John C. Doyle	California Institute of Technology	2/07/04 – 2/13/04
William Frey	General Motors	2/19/04 – 2/20/04
Chetan Gadgil	University of Minnesota	2/09/04 – 2/13/04
Sonja Glavaski	Honeywell	2/09/04 – 2/13/04
Carla Gomes	Cornell University	2/10/04 – 2/12/04
Martin Greiner	Siemens AG-Corporate Technology	2/07/04 – 2/14/04
Ramesh Johari	Massachusetts Institute of Technology	2/08/04 – 2/12/04
Taesung Kim	Seagate Technology	2/05/04 – 2/06/04
Howard Karloff	AT&T Labs - Research	2/08/04 – 2/13/04
Dina Katabi	Massachusetts Institute of Technology	2/08/04 – 2/13/04
Mustafa Khammash	University of California - Santa Barbara	2/08/04 – 2/13/04
Lun Li	California Institute of Technology	2/08/04 – 2/13/04
Steven Low	California Institute of Technology	2/08/04 – 2/10/04
Dariusz Madej	Symbol Technologies	2/26/04 – 2/28/04
Zhuoqing Morley Mao	University of Michigan	2/08/04 – 2/13/04
Sarika Mehra	Institution of Minnesota	2/08/04 – 2/13/04
Andrew M. Odlyzko	University of Minnesota	2/09/04 – 2/13/04
Venkat Padmanabhan	Microsoft Corporation	2/10/04 – 2/13/04
Antonis Papachristodoulou	California Institute of Technology	2/08/04 – 2/13/04
Pablo A. Parrilo	Swiss Federal Institute of Technology	2/08/04 – 2/13/04
Craig Partridge	BBN Technologies	2/07/04 – 2/13/04
Stephen Prajna	California Institute of Technology	2/08/04 – 2/13/04
Michael Savageau	University of California - Davis	2/07/04 – 2/13/04
Karen Sollins	Massachusetts Institute of Technology	2/09/04 – 2/13/04
Werner Vogels	Cornell University	2/08/04 – 2/13/04
Walter Willinger	AT&T Labs - Research	2/08/04 – 2/13/04
John Wroclawski	Massachusetts Institute of Technology	2/09/04 – 2/13/04
Fan Yang	University of Minnesota	2/08/04 – 2/08/04
Fan Yang	University of Minnesota	2/09/04 – 2/13/04
Richard Yang	Yale University	2/07/04 – 2/13/04
Lixia Zhang	University of California - Los Angeles	2/07/04 – 2/13/04
Zhi-Li Zhang	University of Minnesota	2/09/04 – 2/13/04

See also URL: `http://www.ima.umn.edu/people/`