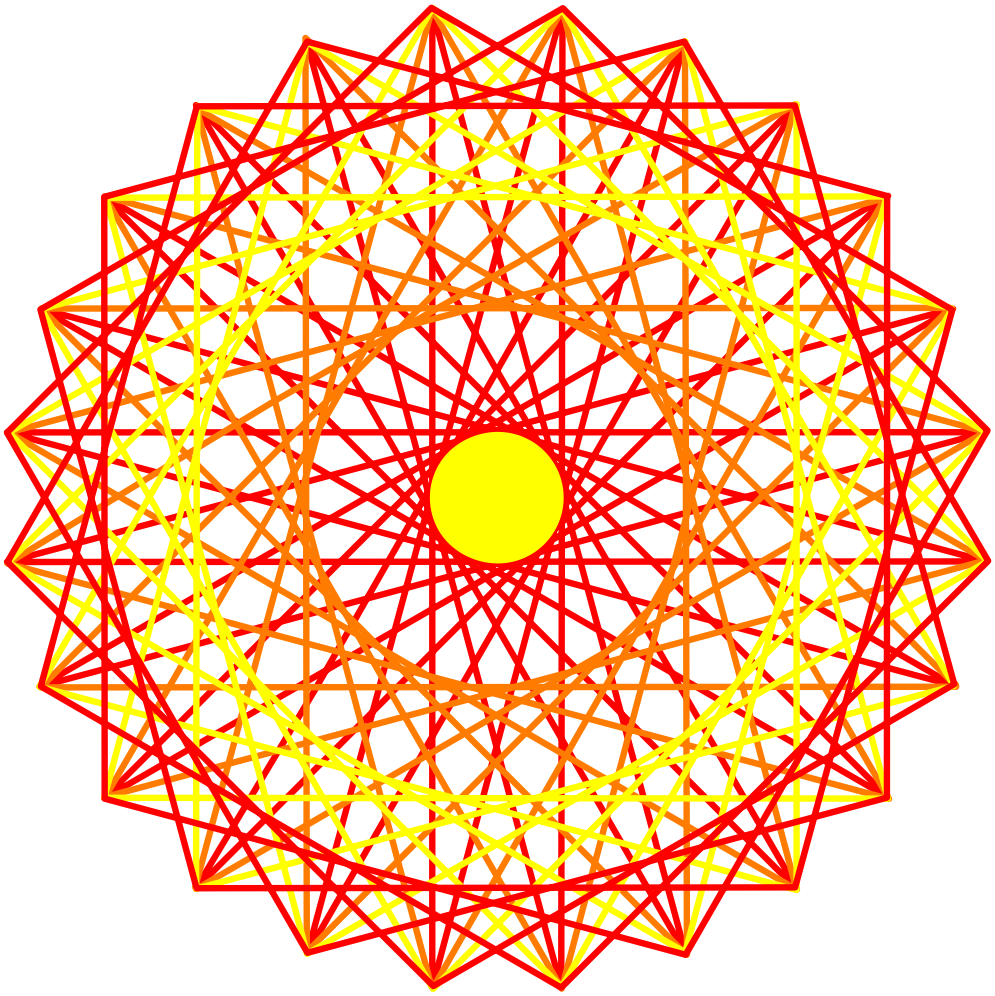
9th Conference for African−American Researchers in the Mathematical Sciences
Purdue University, June 24−27, 2003



CAARMS9
Speaker Abstracts

SPEAKER INDEX

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TUTORIAL ON MEASURE THEORY AND APPLICATIONS TO PROBABILITY

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Part I, Wednesday. Review of continuous functions on metric spaces and particularly their definitions in terms of inverse images of open sets.

Part II, Thursday. An introduction to measurable spaces and measurable functions.

Part III, Friday. Random variables as measurable functions and some basic notions of probability.


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COMBINATORIAL INTERPRETATIONS OF HANKEL DETERMINANTS

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Given a sequence of real numbers $A = \{a_0, a_1, a_2, \ldots\}$, the *Hankel determinant* of order n of A is the determinant of the upper $n \times n$ submatrix of:

$$\begin{bmatrix} a_0 & a_1 & a_2 & a_3 & \ldots \\ a_1 & a_2 & a_3 & a_4 & \ldots \\ a_2 & a_3 & a_4 & a_5 & \ldots \\ a_3 & a_4 & a_5 & a_6 & \ldots \\ \vdots & \vdots & \vdots & \vdots & \ddots \end{bmatrix}$$

If A is a sequence of some combinatorial significance, it seems natural to expect that the Hankel determinants of that sequence will have a related combinatorial meaning. In fact, many authors have found this to be the case for a variety of sequences, including my favorite sequence, the Catalan numbers. In this talk, I will explain by example some of the techniques used by these authors to compute and interpret Hankel determinants, starting with the Catalan number sequence as a base case. As we will see, depending on the given sequence, these computations will yield interesting connections to other combinatorial objects, such as Riordan matrices, continued fractions, orthogonal polynomials, nonintersecting lattice paths and plane partitions. Finally, I will discuss a particular Hankel determinant sequence related to a certain symmetry class of alternating sign matrices and the questions raised by this relationship.

TUTORIAL ON ELLIPTIC CURVE CRYPTOGRAPHY

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Part I, Wednesday: A brief history of cryptography. Just what are elliptic curves and why do they have anything at all to do with cryptography?

Part II, Thursday: More on: the arithmetic of elliptic curves, elliptic curves over finite fields, elliptic curve cryptography and why one would choose to use elliptic curves at all.

Part III, Friday: Challenges, a look ahead and summary.

EFFECTIVE STRATEGIES FOR K THROUGH 20 EDUCATION

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The recent legislation entitled "No Child Left Behind" is setting forth new requirements in K-12 education. This talk will provide an overview of the issues in K-12 math education affecting student achievement and teacher performance. Its purpose is also to provide a basis for developing a better understanding of the requirements necessary for teacher training and analysis of student data. Several strategies are proposed in order to address the challenges resulting from the impact of the new legislation on higher education.


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DIFFERENT EXPRESSIONS OF A MATHEMATICAL OBJECT

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For given odd primes $p, q,\ p > q$, the first mathematical object is the number $N = N(p, q)$ of lattice points on the interior of the rectangle having vertices

$$(0, 0),\ (p/2, 0),\ (p/2, q/2),\ (0, q/2)$$

in the coördinate plane. In the proper setting two different expressions of N reveal an elegant proof of the celebrated Euler-Legendre-Gauss Law of Quadratic Reciprocity.

The second mathematical object is the infinite product

$$P(x) := \prod_{n=1}^{\infty}(1 + x^{2n-1}),$$

which converges for each complex number x such that $|x| < 1$. Two different expressions of $P(x)$ reveal a new recurrence for the partition function $p(\cdot)$. Recall that $p(\cdot)$ is defined (generated) by the infinite-product expansion

$$\prod_{n=1}^{\infty}\frac{1}{1 - x^n} = \sum_{n=0}^{\infty}p(n)x^n,$$

valid for each complex number x such that $|x| < 1$.

A STATISTICAL APPLICATION OF THE KARUSH–KUHN–TUCKER THEOREM: REL

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This research introduces the new nonparametric technique: robust empirical likelihood, REL. Robust empirical likelihood employs the empirical likelihood method to compute robust parameter estimates and confidence intervals. The technique uses the Karush–Kuhn–Tucker Theorem to solve a robust version of the empirical likelihood function, thus allowing data analysts to estimate parameters accurately despite any potential contamination. Robust empirical likelihood's applications include regression models, hypothesis testing, and all areas that use likelihood methods.

MATHEMATICAL MODELLING OF SARS EPIDEMIOLOGY IN TORONTO

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The emergence of severe acute respiratory syndrome (SARS), a highly contagious viral disease that has so far spread to 32 countries, has prompted a global public health campaign in search for effective control strategies. In this talk, a deterministic model will be designed for the epidemiology of SARS in Toronto. The model, which reasonably mimics the SARS outbreaks in Toronto, Hong Kong and Singapore, is used to assess current anti-SARS control measures.

QUANTUM MONTE CARLO FOR ATOMS AND MOLECULES

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The class of ab initio techniques known as *Quantum Monte Carlo* (QMC) methods is used in chemistry to elucidate properties of systems governed by the laws of quantum mechanics. One the most unique aspects of QMC methods is the use of the probabilistic interpretation of the quantum mechanical wavefunction. By not using a purely analytic approximation to the true wavefunction like traditional ab initio approaches, QMC calculations are able to achieve accuracies on par with more expensive methods with less overall computational effort. Because QMC is also a Monte Carlo method, it is possible to estimate a statistical error associated with the calculation; this is unique among commonly practiced ab initio techniques.

This talk will present the background of QMC, including the general motivations and formal development of the method. In addition, examples of the implementation of QMC as a massively parallel method for efficient, accurate calculation of chemical properties related to electronic structure will be presented. This will be done by putting QMC in context with other ab initio techniques and by making comparisons that demonstrate and explain performance differentials in the various methods. A brief discussion of continuing challenges, new directions, and potential applications outside the realm of standard ab initio electronic structure will also be included.

SCALABLE RESOURCE RESERVATION AND ADMISSION CONTROL

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Improving the ability of today's networks to provide cost efficient mechanisms for providing Quality of Service (QOS) guarantees is the the focus of this work. Specifically, this work proposes mechanisms to provide bandwidth and loss guarantees. Cost is regarded in the context of QoS mechanisms that scale in the network core where routers process orders of magnitude more flows than edge-routers. Cost metrics include time taken to establish a reservation, amount of per flow state maintained by routers, amount of signalling needed to establish a reservation and the asymptotic efficiency of the packet scheduling algorithm. This work builds upon advances made with the flow aggregation techniques that were introduced by Differentiated Services (DiffServ) research, advances in measurement-based admission control and FIFO queueing techniques used to preserve established QoS guarantees.

A MECHANICAL MODEL OF TUMOR ENCAPSULATION AND INVASION

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A mathematical modeling framework is presented which describes the growth, encapsulation, and transcapsular spread of solid tumors. The model is based on the physical forces and cellular interactions involved in tumorigenesis and is used to test and compare the active (Foreign Body Hypothesis) and passive (Expansive Growth Hypothesis) hypotheses of capsule formation. The model simulations predict that although an active response can successfully control tumor growth via the deposition of large amounts of collagen, this alone is insufficient for capsule formation. In contrast, a solely passive response is capable of producing an encapsulated tumor with minimal accumulation of connective tissue within the tumor mass. When both mechanisms are operative, the tumor becomes significantly more fibrous and a denser capsule forms. Using a modified version of the model, in which tumor cells are able to cause the degradation of surrounding connective tissue, it is also possible to show that transcapsular spread or invasion may be due tumor-synthesized proteases and their subsequent action.

POTENTIAL OPERATORS METHOD OF INTEGRAL SOLUTIONS OF INITIAL VALUE PARABOLIC EQUATIONS

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The presentation will focus on the new iterative method for establishing the existence and uniqueness of solutions to semi-linear initial value parabolic problems of the type

$$u_t - \triangle u = f(u) + F(x,t);\ x \in \mathbb{R}^n, t > 0 \quad (1)$$
$$u(x,0) = g(x);\ x \in \mathbb{R}^n \quad (2)$$

and of the bi-harmonic type

$$u_t = -\lambda \triangle^2 u + \upsilon \triangle u^{m+1};\ x \in \mathbb{R}^n, t > 0 \quad (3)$$
$$u(x,0) = f(x);\ x \in \mathbb{R}^n \quad (4)$$

when the initial data is in $\mathcal{L}^p$. Much of the talk will center on the investigation of properties of integral solutions to the above problems. In passing, we will also discuss the applications of equations (1) and (2) to modeling cylindrical tumors and equations (3) and (4) to modeling long-range insect dispersals. New directions and open problem will also be presented.

INVERSE, SHIFTED INVERSE, AND RAYLEIGH QUOTIENT ITERATION AS NEWTON'S METHOD

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The inverse, shifted inverse, and Rayleigh quotient iterations are well-known algorithms for computing an eigenvector of a symmetric matrix. In this talk we demonstrate that each one of these three algorithms can be viewed as a standard form of Newton's method from the nonlinear programming literature, involving an ℓ_2-norm projection. This provides an explanation for their good behavior despite the need to solve systems with nearly singular coefficient matrices. Our equivalence result also leads us naturally to a new proof that the convergence of the Rayleigh quotient iteration is q-cubic with rate constant at worst 1.

PERFORMANCE MODELLING OF CALL CENTERS WITH SKILL-BASED ROUTING

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Skill-based routing (SBR) is a sophisticated protocol feature of the call center telephone switch that minimizes the staff but increases agent utilization. According to Gans, Koole, and Mandelbaum, "... the technology has raced ahead of the managers' and academic's understanding of how it may best be used, and the characterization of effective strategies for skill-based routing is an open question at all levels of (the) capacity planning hierarchy..."

We model a SBR call center environment as an $M/M/C/K$ queue with non-preemptive priorities, where the skill set for each agent is predefined. Agents have a single priority skill but may also have a secondary skill and a tertiary skill if not more. We have developed a discrete-event stochastic simulation to analyze this system.

We have also developed two new methods for optimally designing the classical $M/M/C/K$ queue to hold both the steady state blocking probability and the probability of delay (exceeding a specified threshold value) below given tolerance values. One method is an exact search algorithm that uses stochastic ordering results. The other method is asymptotic and achieves optimization by a using heavy traffic analysis. Both methods are compared to industry-accepted practices.

Finally, we develop a heuristic approach to calculating the number of call center agents and telephone lines needed in an SBR environment. We compare our approach to both the known industry-accepted methods and our own simulations.

TALKING DRUMS, MICROPHONES AND AFRICAN-AMERICANS IN TECHNOLOGY

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My first major scientific recognition came after the electret microphone replaced the carbon microphone in telephones throughout the world. While recognition is always appreciated, I had major problems being labeled "the first Black ..." because most early Black contributions to science and technology have either been purposely ignored or just plain lost. Attempts at retrieving our cultural history in technology in specific areas was more difficult then I could imagine. However, New York City's Schomburg Center for Research in Black Culture provided me with the most concentrated collection of resources on these topics.

It did not take me long to find Granville T Woods (1865-1910). He was a prolific Black inventor with more than 35 patents (mostly on mechanical devices) and sold many of them to Alexander Graham Bell. Among the patents purchased by Bell was one for the carbon microphone, which was the microphone of choice by most telecommunications manufacturers until mid 1970s' when the electret microphone replaced it. I also discovered that over 400 US patents were issued to African-Americans before 1900 covering everything from farming tools to medical devices. Communication technology was one of the leading sciences in early African continental development. Talking drums that mimic the human voice, shifted to lower frequencies, were able to transmit messages over distances greater then 20 miles and were utilized by West Africans to control vast empires. This appears to be the first reliable communications system with a range beyond that of the human voice.

Another set of histories relevant to African Americans in technology were a series of events that I had the privilege of being involved in during my 40 year career at Bell Laboratories. In the early 1970's the Black employees of AT&T and Bell Laboratories formed the Association of Black Laboratories Employees (ABLE), aimed at improving diversity in the Bell System. Among its accomplishments was encouraging management to fund numerous programs including the Summer Research Program (SRP) and the Cooperate Research Fellowship Program (CRFP). Both programs were designed to enhance the process for producing the next generation of minority and women scientists, engineers and mathematicians. The SRP and CRFP programs combined have graduated over 500 minorities and women in these fields. One legacy of these 30-year old programs is that 80 of these 500 people are currently professors, deans, and administrators in science and technology at top universities throughout the country.