LINEAR PROGRAMMING: Survey reveals need for speed, reliability

informs

ORMS TODAY

June 2009
Volume 36 • Number 3

O.R. and BIOMEDICINE

Opportunities abound in the interplay between medicine, bioengineering and medical physics

HEWLETT-PACKARD WINS EDELMAN
Tech giant transforms massive product portfolio

INSIDE:

Experience how AIMMS enables you to apply OR successfully

AIMMS® THE MODELING SYSTEM 3

Hassle-free deployment alternatives to end-users

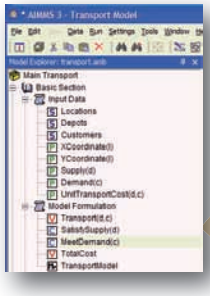
- *Free AIMMS Viewer*
- *Web Services*
- *Excel add-in*
- *COM object*
- *API*
- *etc.*

Fast GUI builder to visualize results and to interact with your model

mosek
Gurobi Optimization
CONOPT
ILOG CPLEX
KNITRO
and many more...

Seamless links to powerful solvers

Point-and-click integration with data sources



Transparent and maintainable model formulation

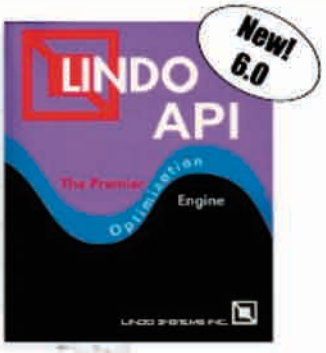
Please visit our website for application examples, industry case studies and a free full trial license.
www.aimms.com

PARAGON Decision Technology

Europe, Middle East & Africa • Haarlem, The Netherlands • Phone: +31 (23) 5511 512
Americas • Kirkland, WA, USA • Phone: +1 (425) 576 4060
Asia Pacific • Singapore • Phone: +65 9640 4182
www.aimms.com • info@aimms.com

Introducing LINDO API 6.0 with New Stochastic Programming Features.

Don't Risk Building Your Optimization Models with Anything Else



In order to accurately reflect today's volatile business environment your models need to take into account uncertainty.
In addition to performance and other enhancements, the newest release of LINDO API lets you incorporate uncertainty into your optimization models.

New Stochastic Programming Interface
+Modeling and optimization for models with uncertain elements via multistage stochastic linear, nonlinear, and integer stochastic programming (SP).
+Extensive set of API functions to setup and solve SP models of all types, including,
+Benders decomposition for large linear SP models.
+Deterministic equivalent method for solving nonlinear and integer SP models.
+Distribution types supported: > 20, e.g., Normal, Poisson, etc.
+User defined functions allowed via call-backs.
+Customized sampling scenarios via the statistical sampling API.

Statistical Sampling API
+Extensive API functions to sample directly from various statistical distributions,
+Variance reduction with Latin-Hyper-Cube and Anti-thetic variates sampling,
+Generation of correlated samples via Pearson, Spearman, or Kendall correlation measures.
+Pseudo random uniform generation via a choice of three different generators.

Simplex Solver Improvements
+Large linear models solve an average of 20% faster with improved primal and dual solvers.

MIP Solver Improvements
+Substantial improvements in all heuristics for finding close to optimal solutions quickly.
+Significant improvements in cuts for certain types of special model structures.

Global Solver Improvements
+Significant improvement in the handling of nonlinear models with quadratic terms, especially non-convex quadratic expressions.

Find out more about LINDO API and its Stochastic Programming features by visiting www.lindo.com.

www.lindo.com

LINDO SYSTEMS INC.

800-441-BEST / 312-988-7422

info@lindo.com

Contents

June 2009 • Volume 36 • No.3

ORMS TODAY

Departments

22

The thin line that separates optimization from agent-based methods.

40

HP wins the "Super Bowl of O.R." by transforming product portfolio.

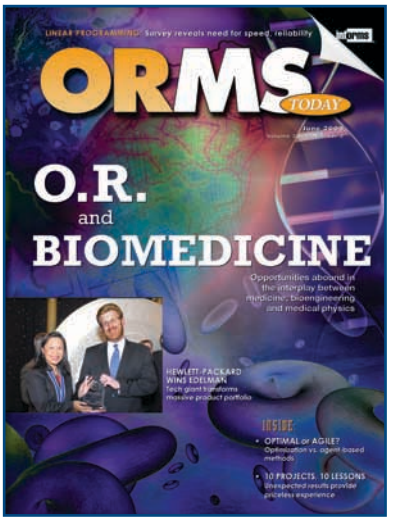
INFORMS News

Cover

Computational Biology

Operations research and computer science have emerged as vital tools for investigating complex biological systems.

© Photographer: Rolffimages | Agency: Dreamstime.com



Features

Computing

OR/MS Today (ISSN 1085-1038) is published bimonthly by the Institute for Operations Research and the Management Sciences (INFORMS). Canada Post International Publications Mail (Canadian Distribution) Sales Agreement No. 1220047. Deadlines for contributions: Manuscripts and news items should arrive no later than six weeks prior to the first day of the month of publication. Address correspondence to: Editor, ***OR/MS Today***, 506 Roswell Street, Suite 220, Marietta, GA 30060. The opinions expressed in ***OR/MS Today*** are those of the authors, and do not necessarily reflect the opinions of INFORMS, its officers, Lionheart Publishing Inc. or the editorial staff of ***OR/MS Today***. Membership subscriptions for ***OR/MS Today*** are included in annual dues. The non-member annual subscription rate is $42, $59 Canada & Mexico and $65 all other countries; the institution rate is $62, $79 Canada & Mexico and $85 all other countries. Single copies can be purchased for $10 plus postage. Periodicals postage paid at Hanover, MD, and additional mailing offices. Printed in the United States of America. POSTMASTER: Send address changes to ***OR/MS Today***, INFORMS-Maryland Office, 7240 Parkway Drive, Suite 310, Hanover, MD 21076.

THE BEST WAY TO TEACH AND LEARN SIMULATION

RISK SOLVER PLATFORM

Risk Analysis is Easy as What-If with our Ultra-Fast, *Interactive* Monte Carlo Simulation.

In true Excel 2007 style, select from galleries, drag and drop to define random variables, simulation outputs, and summary statistics. Then change a number and watch charts *update instantly* with new results.

Use the Full Spectrum of Simulation Methods.

Use any of 45 distributions, 30 statistics and risk measures, rank order correlation, distribution fitting, multi-stream random number generators and variance reduction methods. Create frequency, cumulative, sensitivity (Tornado) and scatter plots effortlessly.

Easily Create Multiple Parameterized Simulations.

Define parameters in seconds, run high speed multi-way parameterized simulations, capture all the results, and produce instant reports plus standard, Overlay, Trend and Box-Whisker charts, without programming.

Teach and Learn Optimization, Decision Analysis, and More with the Same Software.

You can use its powerful simulation features alone – but click a magic wand and Risk Solver Platform becomes the *ultimate* tool for optimization in Excel – from linear mixed-integer to simulation optimization. One simple, consistent user interface makes learning and teaching easier than ever, letting you focus on model-building.

Free Trials and Support for Your Efforts at Solver.com.

Download a free trial of Risk Solver Platform, and learn about the many other ways we can support your teaching and learning efforts – all at www.solver.com.

FRONTLINE solvers

Tel 775 831 0300 • Fax 775 831 0314 • info@solver.com

And the Winner is ...

Perhaps the most impressive legacy of INFORMS' "Science of Better" marketing campaign, besides a good-looking Web site (www.INFORMS.org), is the annual Edelman Awards Gala. If memory serves, the initial goal of the gala was to put on an Oscars-like event that combined presentations by the Edelman finalists and the announcement of the winner with the suspense and glamour of its Hollywood counterpart while attracting a cadre of reporters from the big-time, mainstream business media.

As my main man Meat Loaf so famously sang back in the late 1970s, "Two out of three ain't bad" [1].

All I can say is, my brethren from the mainstream business media missed out, again, on a wonderful event. The 2009 Edelman Awards Gala, held in conjunction with this spring's INFORMS Practice Conference in Phoenix, had everything you could possibly want: the competition was outstanding, the suspense was superb, and the nominees included such renown corporate A-listers as IBM, Hewlett-Packard, Marriott International and CSX Transportation, along with a couple of intriguing international entries, Norske Skog of Norway and Zora of Spain.

To be sure, the "glamour" quotient may not have been quite up to Hollywood standards, but I was certainly impressed by Intel Chairman Craig Barrett who was there to accept the INFORMS Prize. I didn't see Meryl Streep, but I did see Merrill Lynch's Russ Labe, who was one of the Edelman judges. And everyone at the affair at the Sheraton Phoenix Downtown Hotel "looked maaahvelous," on and off the red carpet.

Master of Ceremonies Robert Bixby hit all the right notes at all the right times (funny, reverent, etc.). INFORMS President Don Kleinmutz milked the Edelman moment for all it was worth ("And now, the moment of truth. The envelope, please. Ladies and gentlemen, please join me in welcoming to the stage the winners of the 2009 Franz Edelman Award for outstanding achievement in operations research … (very long pause) Hewlett-Packard!" And the audience liked, they really liked, Kathy Chou, vice president of worldwide commercial sales for HP, who accepted the Edelman Award on behalf of the award-winning team.

In a truly Oscar-esque moment, Chou charged up to the stage along with the rest of the jubilant HP contingent when the winner was announced only to realize she had left her acceptance remarks back at her chair, proving once again that nobody besides the judges knows the Edelman winner before it is announced at the gala.

"This really does feel like the Academy Awards," Chou said upon her return to the stage, notes in hand. "It's one of those things where you have to be prepared ahead of time in case you might win, but I didn't really want to look at my remarks because I didn't want to jinx us. So I put them away and forgot about them."

For more on Chou's thoughts regarding winning the Edelman and HP's efforts in using O.R. to transform its portfolio management that led to the award, see page 40. IORMS

— PETER HORNER, *editor*
horner@lionhrtpub.com

REFERENCE

1. For the uninitiated or for those just looking for some great, old-school operatic rock, check out www.youtube.com/watch?v=p_Tf2lQvDz0. Better yet, get Meat Loaf's classic album, "Bat Out of Hell." And no, I don't get a cut of the royalties.

OR/MS TODAY

INFORMS BOARD OF DIRECTORS

President	Don M. Kleinmuntz, USC and Strata Decision Technology
President-Elect	Susan L. Albin, Rutgers University
Past President	Cynthia Barnhart, MIT
Secretary	Anton J. Kleywegt, Georgia Institute of Technology
Treasurer	Stephen M. Robinson, University of Wisconsin-Madison
Vice President-Meetings	Robin Lougee-Heimer, IBM Research
Vice President-Publications	Terry P. Harrison, Penn State University
Vice President-Sections and Societies	Ariela Sofer, George Mason University
Vice President-Information Technology	Warren Lieberman, Veritech Solutions
Vice President-Practice Activities	R. John Milne, IBM
Vice President-International Activities	Michel Gendreau, Université de Montréal
Vice President-Membership and Professional Recognition	Pinar Keskinocak, Georgia Institute of Technology
Vice President-Education	Jayashankar M. Swaminathan, University of North Carolina
Vice President-Marketing and Outreach	Anne G. Robinson, Cisco Systems Incorporated
Vice President-Chapters/Fora	John W. Fowler, Arizona State University

EDITORS OF OTHER INFORMS PUBLICATIONS

Decision Analysis	L. Robin Keller, University of California, Irvine
Information Systems Research	V. Sambamurthy, Michigan State University
INFORMS Journal on Computing	John Chinneck, Carleton University
INFORMS Online	ManMohan Sodhi, City University London
INFORMS Transactions on Education	James Cochran, Louisiana Tech University
Interfaces	Jeffrey D. Camm, University of Cincinnati
Management Science	Wallace J. Hopp, Northwestern University
Manufacturing & Service Operations Management	Gérard P. Cachon, University of Pennsylvania
Marketing Science	Steven M. Shugan, University of Florida
Mathematics of Operations Research	Uriel G. Rothblum, Technion-Israel Institute of Technology; Nimrod Megiddo (outgoing), IBM Almaden Research Center
Operations Research	David Simchi-Levi, Massachusetts Institute of Technology
Organization Science	Linda Argote, Carnegie Mellon University
Transportation Science	Hani S. Mahmassani, University of Maryland-College Park
Tutorials in Operations Research	Paul Gray, Irvine, Calif.

INFORMS OFFICES **PHONE: 1-800-4INFORMS**

INFORMS Executive Director	Mark G. Doherty
Corporate, Member, Publications and Subdivision Services	INFORMS (Maryland) 7240 Parkway Drive, Suite 310 Hanover, MD 21076 USA Tel.: 443.757.3500 • Fax: 443.757.3515 E-mail: informs@informs.org
Meetings Services	INFORMS (Rhode Island) 12 Breakneck Hill Road, Suite 102 Lincoln, RI 02865 USA Tel.: 401.722.2595 • Fax: 401.722.2951 E-mail: meetings@informs.org

OR/MS TODAY ADVERTISING AND EDITORIAL OFFICE

Send all advertising submissions for OR/MS Today to:
Lionheart Publishing Inc., 506 Roswell Street, Suite 220, Marietta, GA 30060 USA
Tel.: 770.431.0867 • Fax: 770.432.6969

To contact the editor:
Tel.: 770.587.3172 • E-mail: horner@lionhrtpub.com

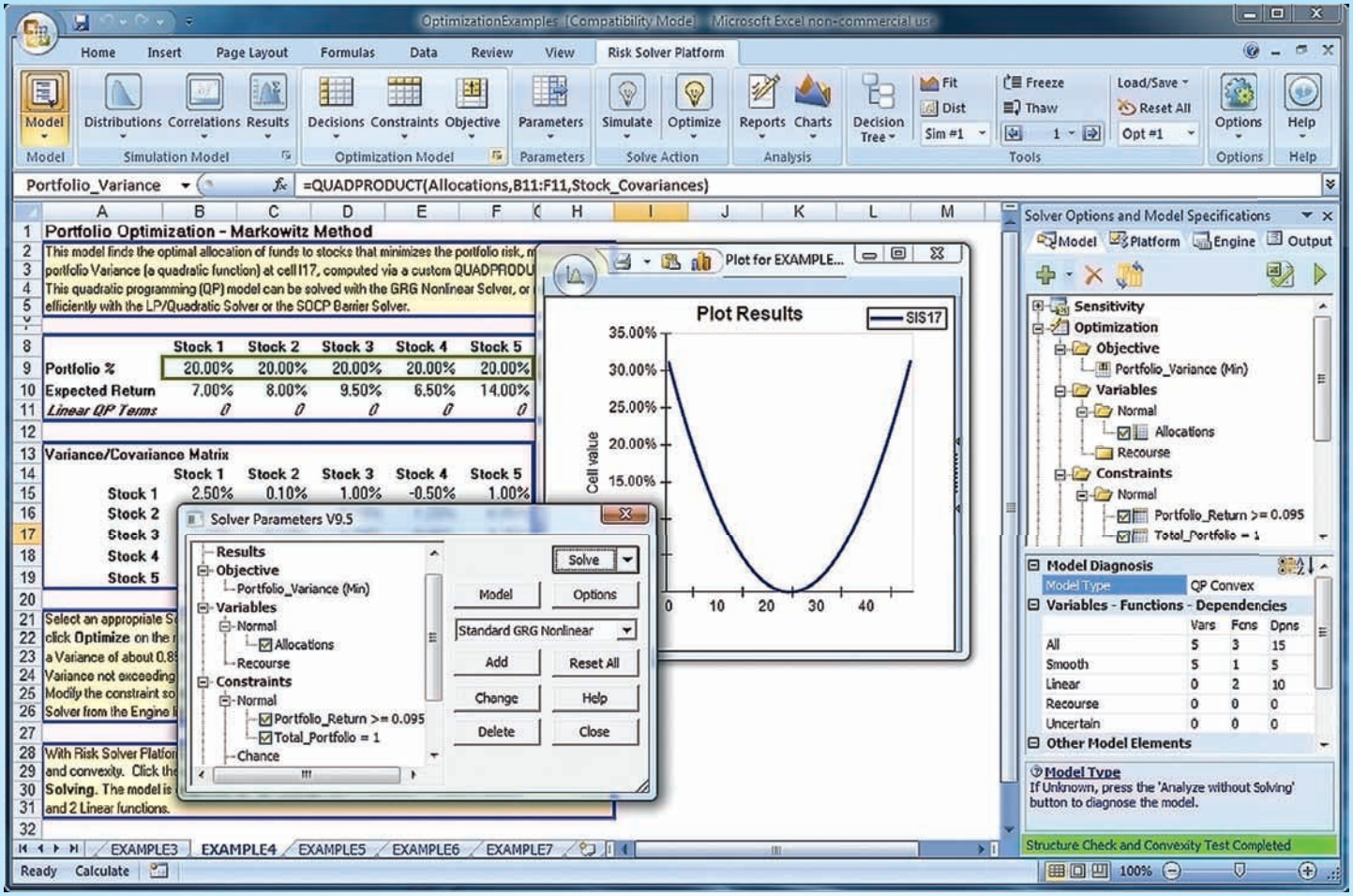
President	John Llewellyn • llewellyn@lionhrtpub.com
Editor	Peter R. Horner • horner@lionhrtpub.com
Associate Editor	James J. Swain
Computer Science Editor	Ramesh Sharda
Software Review Editor	Matthew Saltzman
Art Director	Alan Brubaker • albrubaker@lionhrtpub.com
Production Designer	Kat Wong • katwong@lionhrtpub.com
Online Projects Manager	Patton McGinley • patton@lionhrtpub.com
Employment Advertising	Maria Bennett • bennett@lionhrtpub.com Tel.: 770.431.0867, ext. 219
Advertising Sales Manager	Sharon Baker • sharonb@lionhrtpub.com Tel.: 813-852-9942
Reprints	Kelly Millwood • kelly@lionhrtpub.com Tel.: 770.431.0867, ext. 215
International Media Consultant	Anthony Fitzgerald • mail@afitzgerald.co.uk MMI Ltd. Tel: 44.1488.680623

OR/MS Today Committee
Robert Shumsky, chairman

INFORMS Online	http://www.informs.org
Lionheart Publishing Online	http://www.lionhrtpub.com

THE BEST WAY TO TEACH AND LEARN OPTIMIZATION

RISK SOLVER PLATFORM



The Excel Solver's Big Brother Makes Optimization Easier, More Powerful – and Far More Visual.

From its classic Solver Parameters dialog to its modern Ribbon, modeless Task Pane, and charts to visualize the shape of functions, Risk Solver Platform makes it easier to teach and learn optimization.

Use the Full Spectrum of Optimization Methods.

Ultra-fast linear, quadratic and mixed-integer programming is just the starting point in Risk Solver Platform. SOCP, nonlinear, non-smooth and global optimization are just the next step. Go even further with simulation optimization, stochastic programming, and robust optimization – all at your fingertips.

Go Far Beyond Single Optimization Solutions.

Define parameters in seconds, run high speed multi-way parameterized optimizations, capture all the solutions, and produce instant reports, charts and graphs, without programming. And you can do even more in Excel VBA.

Teach and Learn Monte Carlo Simulation, Decision Analysis, and More with the Same Software.

You can use its powerful optimization features alone – but click a magic wand and Risk Solver Platform becomes a full-power tool for Monte Carlo simulation, with 45 distributions, 30 statistics and risk measures, and a wide array of charts and graphs. One simple, consistent user interface makes learning and teaching easier than ever, letting you focus on model-building.

Free Trials and Support for Your Efforts at Solver.com.

Download a free trial of Risk Solver Platform, and learn about the many other ways we can support your teaching and learning efforts – all at www.solver.com.

FRONTLINE solvers

Tel 775 831 0300 • Fax 775 831 0314 • info@solver.com

INFORMS President
Don N. Kleinmuntz
dnk@strata-decision.com

Thoughts on Publications

Recently, I have been thinking about the business of scientific publications. Our 12 scholarly journals are among our most valuable assets. They have a well-deserved reputation for high-quality articles, with worldwide demand from faculty members and their research libraries. Our members volunteer tremendous amounts of unpaid labor by serving as authors, referees and editors. INFORMS adds significant value by facilitating a rigorous peer review process, applying high standards of professionalism to the publication process, and arranging for archival storage and dissemination of both print and on-line versions. This supports our mission by promoting the growth of scholarly knowledge in our field.

Publications also serve a more pragmatic function: In our 2009 budget, subscriptions and related payments account for 57 percent of revenue, compared to 26 percent for conference fees and 17 percent for dues. In contrast, only 27 percent of expenses are directly related to publications. Conferences are the only other activity that consistently produces a positive financial return, but with a surplus that is one-tenth as large. INFORMS uses the net surplus to support many other nonrevenue producing activities (e.g., awards, education, public outreach, job placement, Web sites and administrative overhead).

We should not assume this operating model will continue indefinitely. Most subscription revenue comes from academic research libraries, which are coping with tremendous financial stress from the economic downturn, dwindling educational and research funding and shrunken university endowments. Another significant stressor is journal pricing. Recent analyses suggest that over the last decade, subscription rates for science, engineering, and technology journals have increased five times faster than the cost of living [1]. For-profit commercial publishers have been particularly aggressive, while not-for-profit scientific societies like INFORMS are more sensitive to research libraries' plight. Direct comparisons make it difficult to characterize commercial publishers' prices as anything other than exorbitant.

Both librarians and researchers are justifiably concerned that high prices prevent rapid and efficient dissemination of findings, deterring scientific progress. This concern has encouraged growth in the open access movement, which seeks to make peer-reviewed literature available on the Internet free of charge to the reader and free of most copyright and license restrictions. In March 2009, the movement received a significant vote of confidence when the Massachusetts Institute of Technology (MIT) faculty unanimously voted to establish an open-access repository of research papers, and mandated that faculty grant a nonexclusive license for MIT to freely distribute their articles on the Internet [2]. Individual faculty members may opt-out on an article-by-article basis, if, for instance, a publisher requires exclusive copyright transfer as a condition for publication. Exclusive transfer of rights is the norm for most scientific publishers, including INFORMS [3]. This creates a decision dilemma for MIT faculty – either benefit from publishing in the traditional journal, which confers on the paper the signal of quality associated with the peer-review process, or deposit in the open-access repository, with the potential to reach a wider audience.

So how should INFORMS respond to these trends? The INFORMS Board will continue our long-standing policy of responsible journal pricing. We are also reviewing our copyright policies to ensure we communicate clearly with prospective authors regarding their rights and responsibilities. Looking a decade or so ahead, if the open access movement continues to grow, it might undermine the economic viability of our journals. While this is far from certain, INFORMS must think about strategic alternatives. Some of these include:

1. Expand our current experiments with no-charge open access journals. *INFORMS Transactions on Education (ITE)*, now in its ninth year, is an open access journal. Several INFORMS sections and societies are working to launch similar efforts. One issue: *ITE* and similar journals generate no revenue. INFORMS subsidizes *ITE* using profit from our traditional journals. The cost of refereeing and publishing these electronic journals are modest, but without additional revenue, expanding our offering of no-charge journals means cutting other programs and services.

President's Desk, *continued on p.17*

> Subscriptions account for 57% of revenue, compared to 26% for conference fees and 17% for dues.

REFERENCES

1. www.sennoma.net/main/archives/2009/04/scholarly_journals_vs_total_se.php
2. http://info-libraries.mit.edu/scholarly/faculty-and-researchers/mit-faculty-open-access-policy/
3. www.informs.org/article.php?id=1548

Are you Paying Too Much for Optimization?

Save on your IT Budget with Free Development Copies of MPL!

In today's challenging economy, many companies are looking for ways to save money, including on the budget for purchasing optimization software. We at Maximal Software, have now decided to fundamentally change how we sell our software, by greatly reducing how much you pay for development copies of MPL, in many cases bringing the actual cost down to zero. This includes introducing the following new special programs:

- Free Development Copies of MPL
- Free MPL with Solver Purchase
- Pay Maintenance Only
- Subscription-based Pricing
- Free Open-Source Solvers
- Affordable Runtime/Floating Licenses
- Free Model Conversion to MPL
- Free Software for Academics

Please visit our Web Site www.maximalsoftware.com or contact Maximal Software directly, to find out more information on how these special new programs can help you save money.

MAXIMAL SOFTWARE

Maximal Software, Inc.
2111 Wilson Boulevard, Suite 700, Arlington, VA 22201 U.S.A.
Tel: (703) 522-7900 Fax: (703) 522-7902
sales@maximalsoftware.com

Maximal Software, Ltd.
Boundary House, Boston Road, London, W7 2QE, UK
Tel: +44 (0)208 4343-641 Fax: +44 (0)208 4343-529
sales@maximalsoftware.co.uk

Teaching Effectiveness Colloquium

BY MATT DRAKE, JILL HARDIN, AND CLIFF RAGSDALE

The 2008 INFORMS Teaching Effectiveness Colloquium (TEC) marked a turning point for INFORMS' educational programs. Prior to last year, the forum traditionally held two pedagogical meetings each year: the original daylong TEC the day before the INFORMS Annual Meeting and the multiple-day Teaching of Management Science (TMS) Workshop held in the summer. While this model was highly successful for several years, participants' budget constraints limited attendance in recent years. INFORMS is committed to offering educational programs on pedagogical methods for operations research and management science, so the organization added an extra day to the 2008 TEC filled with some of the content usually covered at the TMS Workshop.

On the heels of the success of last year's revamped TEC we invite you to consider attending this year's event. As co-chairs of the Colloquium, Matt Drake and Cliff Ragsdale are putting the final touches on an exciting two-day program that we hope will provide valuable information to academics at all stages in their careers. The 2009 TEC will be held in San Diego, Calif., on Oct. 9 and 10, the Friday and Saturday preceding the INFORMS Annual Meeting. The program runs all day both days from 7:30 a.m. through the early evening, followed by a group dinner each night.

The dinner on Friday night will be held with the participants of the other colloquia and will include a welcome address by Don Kleinmuntz, the president of INFORMS. The TEC participants will also be able to interact with each other, with the colloquia speakers and with other colloquia participants at breakfast, lunch and several refreshment breaks throughout the two days.

The program is designed to provide a balance of coverage between general theories about student learning and specific classroom innovations for teaching operations research and management science. On the first day Harvey Brightman, Regents' Professor at Georgia State University, will present several interactive sessions on assessing student learning, designing and organizing courses and strategies for teaching difficult topics to students. Brightman has conducted research in management and decision science pedagogy for more than 20 years, and he has actively mentored many junior faculty members at Georgia State to become better teachers.

The second day of the program focuses on specific pedagogical techniques and strategies for improving students' comprehension of management science material and increasing student interest in the classroom. Selected topics of these presentations include active learning, guiding student research projects and practicums, and introducing personal response devices (i.e., handheld clickers) into the classroom. The entire TEC program culminates in a panel discussion of cutting-edge teaching methods and fielding questions from the audience.

Following the presentation, the panelists will break into small groups with the TEC participants to facilitate a small group discussion of the participants' specific issues with their own courses. We encourage all TEC participants to bring to the colloquium any syllabi, assignments or lecture notes that they would like to discuss during this valuable interactive opportunity. In response to comments about previous TECs, we are excited to offer this year's participants the time to consider the colloquium's information in light of their own courses within the colloquium itself. This should provide more of a tangible benefit to all participants as they head back to their home institutions after the colloquium.

Perhaps the best part about the TEC is that each academic department offering regular courses in operations research, management science or one of its constituent disciplines can nominate one of its members to attend the TEC at no charge (provided the participant registers and pays for the INFORMS Annual Meeting as well). Any second participant from a single department must pay only $150, and each additional participant from the department must pay $300. Eligible participants are members of INFORMS who are tenured or tenure-track faculty members in one of INFORMS' constituent disciplines or are advanced doctoral students who are within one year of completing all of the requirements for a Ph.D. degree.

Nomination packets must be received by July 15, 2009. These packets can be sent care of Matt Drake, Duquesne University, 600 Forbes Ave., Pittsburgh, PA 15282, USA. A completed nomination packet includes:

- letter of recommendation from a department chair;
- list of operations research or management science courses that the nominee teaches or is expected to teach;
- list of INFORMS TEC and other workshops that the nominee has attended in the past two years;
- full contact information for the nominee; and
- departmental contact information for invoicing (if department is nominating more than one person).

We hope that you will take advantage of this wonderful opportunity to hone your skills in the classroom and to build your network of contact in the field. Please contact us or visit the homepage of the Combined Colloquia (http://meetings.informs.org/sandiego09/colloquia.html) if you have any questions. We look forward to seeing you in San Diego! IORMS

Matt Drake *(drake987@duq.edu) is an assistant professor of supply chain management in the Palumbo-Donahue Schools of Business at Duquesne University.*

Jill Hardin *(jrhardin@vcu.edu) is an associate professor in Statistical Sciences & Operations Research at Virginia Commonwealth University and is the chair of the 2009 INFORMS Combined Colloquia.*

Cliff Ragsdale *(cliff.ragsdale@vt.edu) is the Bank of America Professor of Information Technology in the Pamplin College of Business at Virginia Tech.*

Why Is CPLEX® Greater Than Ever Before?

IBM ILOG

CPLEX

greater than > ever before

It's the World's Most Trusted Solver + Over 800 OR Professionals!

IBM ILOG CPLEX® is the gold standard to which all solvers are compared and will continue to define the leading edge in the industry as the world's most trusted optimization software for mission-critical applications.

Today, more than 1,000 universities use IBM ILOG CPLEX for research and teaching, and over 1,200 customers, including over 160 of the Global 500, use IBM ILOG CPLEX in some of their most important planning and scheduling applications.

The MPL Modeling System has worked with CPLEX now for over 15 years, and supports all the advanced algorithms and features its customers require.

As a special offer, we will give a Free Development Copy of MPL to anyone who purchases a CPLEX solver from Maximal. Please visit our web site www.maximalsoftware.com or contact Maximal Software directly for more details.

MAXIMAL SOFTWARE

Maximal Software, Inc.
2111 Wilson Boulevard, Suite 700, Arlington, VA 22201 U.S.A.
Tel: (703) 522-7900 Fax: (703) 522-7902
sales@maximalsoftware.com

Maximal Software, Ltd.
Boundary House, Boston Road, London, W7 2QE, UK
Tel: +44 (0)208 4343-641 Fax: +44 (0)208 4343-529
sales@maximalsoftware.co.uk

Wikipedia: No Country for Old Men

BY MANMOHAN S. SODHI

Recently, I tried to post an entry on Wikipedia. I browsed around at first, read directions for first-time users and then created an entry about "Six Sigma Pricing." This was a concept I proposed with a co-author, Navdeep Sodhi, in an article in the *Harvard Business Review* in 2005 ("Six Sigma Pricing") and subsequently in a book published by FT Press/Pearson in 2008 ("Six Sigma Pricing: Improving Pricing Operations to Increase Profits"). The concept and book received favorable reviews. I also heard from consultants that they have tried it or were starting Six Sigma Pricing practices in their companies. So I thought it would be worthwhile creating a Wikipedia entry. However, besides having been unable to do so, the experience of dealing with Wikipedia volunteers has left me shocked, like the sheriff in "No Country for Old Men."

I first copied a similar entry from Knol [another online information source: knol.google.com], created by my co-author, just to dip my toe in Wikipedia water. Within seconds, there was a message about copyright violation giving the Knol entry's URL along with instructions on how to contest that. Accordingly, I contested the violation with an explanation and said that I would edit the entry. Understandably, however, the entry was deleted along with my message.

I then created another entry. Almost immediately there were messages contesting my entry. One Wikipedian recommended I be banned from Wikipedia! Other messages recommended that the entry be deleted on grounds the entry was not notable and referred only to my own work ("conflict of interest"). To respond, I provided other references from within Wikipedia, other articles and from the Web.

I continued editing the entry to expand the content and to address these comments. Pretty soon, the comments on the discussion page became out-of-synch with the entry. Then all of a sudden, all the material I had provided to address the comments was deleted by a Wikipedia editor and I could not retrieve it. (I learned firsthand that Wikipedia's assertion that you can get earlier versions back is false; editors delete material so you cannot retrieve it.) Now the objections looked valid!

I then posted messages to some of these Wikipedians on their respective "talk" pages (aka Wikis) asking why they were deleting my text responding to their comments in the article. One person responded that because my article was marked "conflict of interest," I could not edit the entry. (Actually I could, but they would delete it.) He recommended I edit the "talk" page instead to solicit comments first – I did that and then someone deleted that page. Then all that was left was "Afd" – the article-for-deletion discussion page – but my responses there were mostly ignored. Each new entry would cite a previous person's comment, without my response, and say that they agreed with deleting the entry, although, thankfully, a majority felt I should not be banned.

Finally, I left messages at the individual editors'/Wikipedians' Wiki pages for advice. This elicited a clear conclusion: The entry could not be published, as the concept had not had enough impact on the business world. I needed to show, besides the application in the *Harvard Business Review* article, another application by someone else that was also published. Perhaps over time, someone else would write such an article and then I could try again. This would effectively mean two articles in *HBR* on the same concept by different authors! At that point, I gave up.

It is tempting to compare Wikipedia with a good research journal's editorial process. The bar for "notability" seems rather high, at least in my experience, although it is hard to imagine that even a tiny fraction of Wikipedia's 2.9 million or so articles in English meet that standard.

Unlike a journal, though, on Wikipedia the editors can simply edit your article to make sure their comments ring true! I lost a few hours of work making the changes the editors/reviewers asked for and then those changes were deleted. Also, different editors/reviewers working independently means the price of their inconsistencies is paid by the hapless author. Asking me to respond on different pages with someone else deleting the pages or my changes did not help me, although it helped build consensus among the patrol members because they could only see what was objectionable to them in the first instance.

I accept being rejected – after all, this is something all academics get used to in the publication business – but I cannot fathom the malice of an editor(s) in selectively deleting material in an entry. I also do not understand how volunteers who want to help disseminate knowledge would benefit from banning me from Wikipedia.

The good side is that I lost only a day or so struggling with Wikipedia. Then I learned about another person's experience. He had tried to create a Wikipedia entry about a deceased relative, referring to several books and articles published both by and, significantly, about this relative; however, after a week of his protests and changes, his entry was rejected on the same grounds that mine was: conflict of interest!

Wikipedia is an important addition to world knowledge and we all benefit from robust editorial processes. Indeed, Wikipedia has been blamed for inaccuracies and self-promotional material in the past. To that extent, the editors and other Wikipedia volunteers help the rest of us. Yet, their ways of manhandling authors of new entries suggests that creating entries there is something to avoid although I did read a newspaper story about a high school dropout who created 400+ entries posing as a classics professor. Overall, my experience of Wikipedia was like that dealing with a gang of marauding young men roaming around the countryside looking for victims—yup, no country for old men. IORMS

ManMohan S. Sodhi *(M.Sodhi@city.ac.uk) heads the Operations Research group at Cass Business School in London.*

Attention Members: We Need Your Help

Join our journal grassroots effort and recommend INFORMS journals to your institutional library

You know how much your INFORMS journals mean to you. They are your window on the world of operations research and analytics.

Please help ensure that the next generation of O.R. professionals may rely on INFORMS journals by recommending them to your institutional library. Your recommendation is critical to ensuring the broadest dissemination of this indispensable information.

To recommend missing INFORMS journals to your library, go to **http://grassroots.pubs.informs.org** and search for your institution's subscription. If your institution is missing a journal(s), send a friendly recommendation to your librarian via an already-composed email from INFORMS.

Thank you for your dedication to INFORMS and the profession.

informs® www.informs.org

To Queue or Not to Queue

BY JOHN TOCZEK

Grocery stores are one of the last commercial entities that continue to use the multiple-queue, multiple-server method for providing service to their customers. Banks and post offices have adopted a single-queue, multiple-server method that not only services customers faster but is a fairer system for providing service.

Let's compare these two queueing methods to see how much extra time a customer spends in a traditional queue versus the proposed queue.

Traditional queueing: On a typically busy day at the local grocery store, customers enter one of three queues in order to check out and pay for their groceries. They arrive at the checkout lanes with an interarrival time of two minutes, exponentially distributed. A cashier can scan a customer's groceries and finish on average in five minutes, also exponentially distributed. When selecting a queue, the customer will always choose the line with the fewest people waiting. For simplicity, let's assume that once a customer chooses a lane for checkout, he cannot move to another line.

Proposed queueing: The newly proposed queueing system (Figure 1) has the same arrival and checkout times as the traditional queueing model. But now there is only a single queue where customers wait until a checkout station is empty. Once a checkout station is empty, the customer proceeds immediately to that open station.

Question: How much less time on average (in seconds) will a customer have to wait in line if the grocery store switches from the traditional to the proposed queueing system?

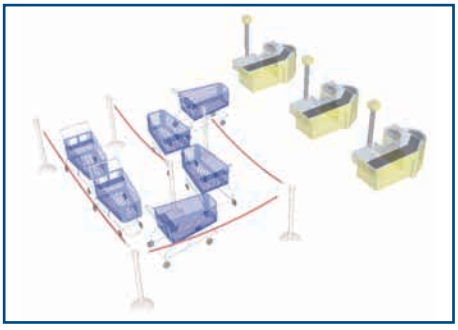


Figure 1: Proposed queue.

Send your answer to puzzlor@gmail.com by Aug. 15. The winner, chosen randomly from the correct scores, will receive an "O.R. The Science of Better" T-shirt. Congratulations to Larry Robinson for correctly solving February's PuzzlOR. Past questions and answers can be found at puzzlor.com. IORMS

John Toczek *(toczek@gmail.com) is the senior decision support analyst for ARAMARK Corporation in the Global Risk Management group.*

OptiRisk SYSTEMS

www.optirisk-systems.com

INVESTOR IN PEOPLE
BS EN ISO 9000 : 2000

Products

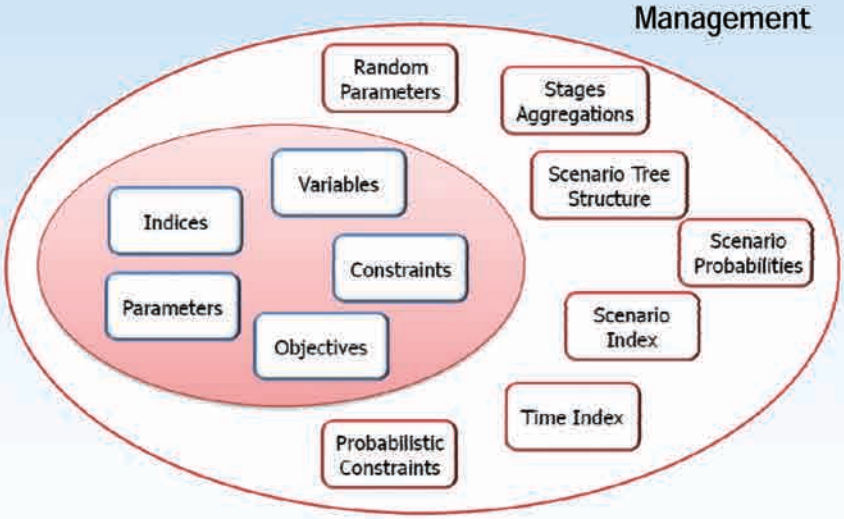
- ✓ Modelling Tools
  - AMPL
  - AMPLStudio
  - AMPLCom
- ✓ Solvers
  - CPLEX(Full Range with AMPL)
  - FortMP (SSX, IPM, MIP, QP, QMIP)
  - FortSP
  - KNITRO
  - MOPS
- ✓ Add-on
  - FortMP (MEX file for MATLAB)
- ✓ Stochastic Extensions
  - SAMPL/SPInE

Services

- ✓ MP Modelling
- ✓ MP Solver Tuning
- ✓ Uncertainty and Risk Analysis/ Modelling
- ✓ Outsourced MP Modelling

Training

- ✓ Linear & Integer Programming
- ✓ Stochastic Programming
- ✓ Quadratic Programming
- ✓ Portfolio Planning
- ✓ Asset & Liability Management



PARTNERSHIPS:

As a leader in the provision of optimisation and risk solutions, we have set out to realise our mission in partnership with the following Optimisation service providers.

ILOG an IBM company

ILOG is the leading supplier of advanced software components for optimization, business rules and visualization.

AMPL LLC

AMPL is a comprehensive and powerful algebraic modelling language for linear and nonlinear optimization problems, in discrete or continuous variables.

Ziena

Ziena is a leader in non-linear optimization software and solutions.

MOPS

MOPS® is a high performance solver system which processes large-scale linear (LP), integer and mixed-integer optimization models (IP).

Contact OptiRisk Systems
One Oxford Road, Uxbridge, UB9 4DA, UK
Tel: +44 (0)1895 819 483
Fax: +44 (0)1895 813 095
Email: info@optirisk-systems.com

US Contact AMPL LLC
Fax: +1 425 940 6286
Email: info@ampl.com

Who's SORiors Now?

BY VIJAY MEHROTRA

In the immortal words of Michael Palin from Monty Python's Flying Circus, "I'd like to have an argument, please" [1]. Our topic today will be "Soft O.R."

Here's my quick recap of a recent article by John Mingers [2] and the Letter to the Editor [3] signed by Mingers and 40+ colleagues (both published in the April issue of *OR/MS Today*):

1) Modern organizations and systems are filled with ill-defined operational and decision-making challenges that feature multiple stakeholders, diverse objectives, limited data and/or difficult-to-detect but very real constraints, relationships and obstacles to change.

2) Such situations (Ackoff [4] long ago referred to them as "messes" while Mingers calls them "wicked problems") are not immediately amenable to the application of mathematical models. However, there is a growing set of relevant and useful techniques that are collectively coming to be known as "Soft O.R."

3) Mingers and his colleagues argue that Soft O.R. should be acknowledged as a "valid, and valued, part of the O.R. discipline." However, Soft O.R. is "virtually ignored within the United States, both in educational programs and in the major journals," and thus the public proponents of Soft O.R. (referred to here as the "SORiors") call for a "a debate within the pages of *OR/MS Today* with senior U.S. academics/practitioners, especially journal editors."

Responding in his role as current editor-in-chief of the journal *Operations Research,* David Simchi-Levi basically says "NIMJ!" (Not In My Journal!). The money quote: "… our objective is to serve the community by publishing high quality papers that are based on rigorous mathematical models and demonstrate potential impact on practice" [5]. I heartily applaud Professor Simchi-Levi for engaging in the conversation and for his honesty (although I can't help but believe that having actual managers and executives evaluate the "potential impact on practice" would result in a very, very different journal). In any case, I suspect most other INFORMS journal editors would admit – in private if not in public – to sharing this math-centric perspective.

Look, I'm a big believer in the value of mathematical models, just like everybody else who reads this magazine. But by largely excluding Soft O.R. from our journals and our classrooms and our story of who we are and what we are capable of, we do a huge disservice to almost everyone. Our students suffer by being ill-prepared to deal with many of the commonplace complexities of today's world that are conveniently absent from their courses. Many prospective clients and would-be champions of O.R. simply cannot find a way to answer the question of what we can actually do for them, which in turn deprives us of the opportunity to discover and deliver the next wave of valuable applications (many of which would, ironically, stimulate a lot of new mathematical research and development).

Worst of all, this narrow math-only point of view tarnishes the proud legacy of operations research and management science, which emerged from the interactions between talented individuals from a variety of fields while focusing their collective talents on real-world problems.

Don't just take my word for it. Check out some of the membership statistics presented by INFORMS President Don Kleinmuntz in his last President's Desk column in this magazine, ironically titled "Value Propositions" [6]. In a time of exploding interest in using mathematical models in business, in a world where data is more plentiful than ever, our august professional society is nevertheless slowly contracting. And it is no secret as to why: throughout my career and most recently while serving on the INFORMS Marketing Strategy committee, I have heard many first-hand tales of how the academic O.R. community is not interested in or able to connect with the very people who are most eager to utilize our analytic capabilities.

What do I propose to do about the SORiors request for engagement with the U.S. O.R. community? Well, for starters, I have a paper [7] coming out later this summer that provides an example of a highly successful Soft O.R.-based project (and here's a shout-out to *Interfaces* Editor-in-Chief Jeff Camm and an anonymous area editor for their support in publishing this paper even though it features only a modicum of mathematical content). Read it and let me know what you think.

More significantly, as the area editor for special editions for *INFORMS Transactions on Education* (www.informs.org/site/ITE/), I hereby officially invite one or two recognized and energetic leaders in the Soft O.R. field to work with me by serving as guest editors of a newly proposed – right here, right now – special edition of *ITE* on the theme of "Effectively Teaching Soft Operations Research Methods."

My expectation is that this special edition will have a significant impact on the teaching of Soft O.R. in the United States. My sense is that there is a sizable but largely invisible group that is ready to offer a broader perspective or O.R. to our digital-age students, who are perpetually hungry for knowledge and skills to help them succeed in an increasingly competitive and complex world. But most faculty members face the practical problem of having neither the teaching strategies nor the curricular resources for incorporating Soft O.R. techniques into our courses, a potentially huge barrier to making dramatic changes. Can you help us overcome these obstacles?

SORiors, I am really glad you spoke up. Seriously. Call me. Let's get to work. IORMS

Vijay Mehrotra *(drvijay @ sfsu.edu) is a faculty member in the Decision Sciences Group in the College of Business at San Francisco State University.*

REFERENCES

1. See the whole sketch at www.youtube.com/watch?v=k3HaRFBSq9k
2. www.lionhrtpub.com/orms/orms-4-09/frsoft.html
3. www.lionhrtpub.com/orms/orms-4-09/frletters.html
4. Ackoff, R. L., 1973, "Science in the Systems Age: Beyond IE, OR and MS," *Operations Research,* Vol. 21, pp. 661-71.
5. www.lionhrtpub.com/orms/orms-4-09/frletters.html and scrolling down to the bottom of the page.
6. www.lionhrtpub.com/orms/orms-4-09/frpresident.html
7. Mehrotra, V. and Grossman, T., 2009, "OR Process Skills Transform an Out of Control Call Center into a Strategic Asset," *Interfaces,* July/August 2009 (to appear).

Edelman Winner, Rhodes Scholar, Baseball Star & March Madness

BY BARRY LIST

The big news for INFORMS in recent months was the Franz Edelman competition. Hewlett-Packard won the competition, but for some time INFORMS has been insisting that all the finalists are, in a sense, winners. The press took note of this: Below you'll see not only a *New York Times* blog about winner HP, but also a *BusinessWeek* article about finalist Norske Skag, a newsprint manufacturer that has used O.R. to bring dignity to downsizing.

The Edelman Award wasn't the only O.R. topic making news. Math crunchers' fascination with sports took some surprising turns, with basketball fans updating their annual forecasting methods for predicting the Final Four, and two Princeton financial engineering students displaying an aptitude for pitching that has made Major League Baseball take notice.

Also in the news is a fascinating West Point cadet who will be the subject of a profile in an upcoming issue of *OR/MS Today*.

Heard the news from INFORMS? Your professional society is now podcasting interviews with operations researchers working on fascinating challenges. Visit www.scienceofbetter.org and www.informs.org, and download the new selections

A PR opportunity remains for operations researchers: Discoveries and Breakthroughs Inside Science (DBIS), the joint program that allows researchers to communicate studies with broad application to the public via local TV news, continues to offer INFORMS members the chance to bring their research to the television and computer screen. Share your important research! Visit the INFORMS Newsroom at www.informs.org and follow the easy steps to explaining your work to DBIS editors.

Remember to share your news making research with the INFORMS Communications Department. Contact INFORMS Communications Director Barry List at barry.list@informs.org or 1-800-4INFORMs.

Now, the news bits:

"In a twist that must make [HP Chairman and CEO Mark V.] Hurd salivate, the researchers have also put their minds toward improving H.P.'s supply chain through a tool called R.C.O., or Revenue Coverage Optimization, which won a prize this week from the Institute for Operations Research and the Management Sciences.

"H.P.'s researchers gathered as much of the company's sales data as possible and came to some startling conclusions."

– New York Times, Bits blog, April 29

"By building a detailed model of its global operations, [Franz Edelman Award finalist] Norske Skog has been able to identify what to eliminate, right down to individual machines. Its tool fits into the field of applied math known as operations research. Originally harnessed in the 1940s to fine-tune logistics, OR is reaching into new fields, including corporate strategy. Norske Skog's analytical approach has even won the grudging approval of union workers. 'They were able to convince us that the numbers were correct,' says global employee representative Kåre Leira."

– BusinessWeek, April 30

"Firstie Joshua Lospinoso, company B-1, will be deferring his NSF scholarship for awhile, as he will be studying in Oxford, England, as a recipient of a Rhodes Scholarship. He will study statistics. 'I will be studying for three years at Oxford to get my Ph.D.,' the economics and operations research major said. 'Then I want to spend some time in the infantry. After that, I will utilize the NSF scholarship to study social network analysis. I would like to go into military intelligence. Eventually, I want to come back to West Point to teach.'

"As long as recipients are in the active Army, they can defer the scholarships, as Lospinoso is doing.

"The NSF offers scholarships in science, technology, engineering and mathematics and provides funds for scholarships to encourage academically talented but financially needy students."

– PointerView, April 30

"Princeton University's David Hale has more than an Ivy League business education as he sets out for the working world. He's got stuff.

"His fastball has enough speed and movement – 'stuff' in baseball lingo – to draw 20 radar-gun toting Major League Baseball scouts to watch him pitch against Cornell University in advance of the June 9-10 draft. He's among the top 75 prospects and No. 1 from the Ivy League, according to *Baseball America* magazine.

" 'He could be a second-rounder or more likely a third- rounder,' said Aaron Fitt, the magazine's college baseball writer. 'There's 50 rounds in the draft, so for a guy to go in the top three is a pretty big deal.'

"Hale, a 21-year-old junior from Marietta, Ga., majoring in operations research and financial engineering, said he's already decided that he'd rather play minor-league baseball than return to Princeton and a possible career on Wall Street."

– Bloomberg News, May 6

"[Pittsburgh Pirates pitcher Ross] Ohlendorf graduated from Princeton with a degree in operations research and financial engineering, so he's not about to be intimidated by a few charts and graphs."

– ESPN, April 28

"As long as [Cornell's Mark] Eisner specified he was applying only for a spousal benefit and not for the benefits he had earned himself, he could continue to build his own 'delayed retirement' credits until 70. He got a $490 a month spousal stipend, plus a check from Uncle Sam for $13,595 in back spousal benefits. Then, in July 2008, when he turned 70, he started collecting his own $2,700-a-month benefits instead. Paula's check went

up a bit too, since she became eligible for a spousal stipend larger than the benefit she had earned on her own.

"What's the best way to maximize your Social Security take? As Eisner's experience shows, the answer isn't always simple. It helped that he has a Ph.D. in operations research, the science of optimizing the allocation of scarce resources over time and uncertain conditions. To optimize your retirement, you need, if not a doctorate, at least an understanding of Social Security's quirks, particularly as they relate to couples. It's worth the effort."

– Forbes.com, April 7

"The baseball season is about to begin, and a professor of mathematics has developed an intricate model to predict the winners of the American and National leagues; his model computes the probability of a team winning a game against another team with given hitters, bench, starting pitcher, relievers and home field advantage

"Yogi Berra said that 'Predictions are very difficult, especially about the future.' This difficulty has not deterred mathematician Bruce Bukiet. The New York Yankees, Boston Red Sox, Cleveland Indians and Los Angeles Angels should make the playoffs in the American League (AL) in 2009 with most other teams lagging well behind. The National League (NL) should see another very tight race in the Eastern Division as has occurred in recent years...

"*Operations Research* published Bukiet's mathematical model on which his predictions are based."

– HSDailyWire, April 3

"Here's a hot tip: The University of North Carolina is going to win the NCAA men's basketball tournament.

"At least that's the prediction of [operations researcher] Joel Sokol, a Georgia Tech professor whose statistical model correctly selected the Final Four, championship game and winner of last year's tournament.

"Be glad he's not in your office's betting pool.

"Finding some kind of rationality in March Madness, which starts in earnest Thursday, has been an American pastime for decades. Tournament brackets are everywhere, and from sports TV to the dinner table, everyone seems to have predictions about which team will claim the top spot, and why.

"But in recent years, 'bracketology,' as sorting out the single-elimination basketball tournament is sometimes called, has increasingly become the scientific endeavor its name suggests. It's even something on which university professors and professional statisticians stake their reputations."

– CNN, March 18

"For budding 'bracketologists' busily weighing picks for their annual March Madness office pool, a University of Illinois professor has some advice on how to pick winners: In the later rounds of the tournament, ignore a team's seeding, which is a statistically insignificant predictor of a team's chances of winning.

"According to Sheldon H. Jacobson, a professor of [operations research,] computer science and the director of the simulation and optimization laboratory at Illinois, for the top three seeds in the four regional brackets, the road to the Final Four of the NCAA men's Division I basketball championship will most likely play out according to their initial seeding in the first three rounds of the tournament – that is, the higher-seeded teams will most likely beat their lower-seeded opponents."

– University of Illinois, March 16

"Alas, in practice most of the currently promulgated guidelines lack that kind of rigorous scientific foundation. For example, as the science reporter Ronald Winslow recently reported in *The Wall Street Journal,* 'just 11 percent of more than 2,700 recommendations approved by cardiologists for treating heart patients are supported by high-quality scientific testing, according to new research.'

"That circumstance alone justifies spending billions more than we traditionally have on operations research for an industry that now absorbs $2.5 trillion or close to 17 percent of our gross domestic product. Why anyone would oppose that kind of research challenges one's imagination." IORMS

– Economix, New York Times blog, March 13

Barry List *(barry.list@informs.org) is the director of communications for INFORMS.*

President's Desk, *continued from p.6*

2. Experiment with "author-pays" open-access. Some open access journals use an approach where authors – or their employers or research sponsors – cover the publisher's costs for review and publication. There is no charge to readers with Web access, removing barriers to dissemination. However, this does little to relieve financial pressure on research institutions, only shifting the burden from libraries to academic departments and programs.

3. Find new varieties of publication revenues. As I noted in my April column, our largest potential audience are practitioners. *Interfaces,* our most practice-oriented publication, has outstanding content on applications, but is distributed primarily through academic libraries. How should we reach those practitioners who are not members and lack access to a research library? Could we develop one or more magazines (on-line or print), perhaps supported by advertising revenues? These would not be scientific journals, but rather, publications with accessible content written specifically for practitioners.

4. Find new non-publication revenues. We can lessen our dependence on journals by diversifying our revenue base, perhaps attracting new dues-paying members, developing new conferences or growing existing conferences. Other organizations like ours often serve professionals and grow membership by offering continuing education programs.

These ideas illustrate some possibilities, but do not exhaust the potential strategies. Even if open-access does not undermine our journals, some of these strategies may still be worth pursuing. The success of our journals has put us in a strong position, since we have the financial resources to experiment. The main point to remember is that maintaining the status quo is not an attractive option. IORMS

ACKNOWLEDGMENTS

My thoughts have benefited from discussions with numerous colleagues, including INFORMS Past-President Cynthia Barnhart, *Interfaces* Editor-in-Chief Jeffrey Camm, Vice President for Publications Terry Harrison, Director of Publications Patricia Shaffer and, most of all, President-Elect Susan Albin.

Economic Recovery Through Supply Chain Reasoning

BY MANMOHAN S. SODHI AND CHRISTOPHER S. TANG

With economic gloom spreading globally, governments are under pressure on many fronts: families want relief on mortgages in the United States, the auto industry wants help in western countries, and banks need more help despite questionable results thus far. The economy itself is a complex network that defies a clear starting point. How should governments develop and explain an integrated set of initiatives as they face a growing number of demands? Businesses too have to make sense of the apparent pot pourri of government initiatives.

We advocate approaching economic recovery from a supply chain perspective.

A Supply Chain of Sectors

Viewing the economy as a supply network of industry sectors harks back to the late 1940s when Wassily Leontief, a Nobel Laureate in Economics, proposed input-output modeling. Each sector receives flows from other sectors and transforms them into flows for other sectors. The well-being of any sector is connected to that of other sectors in this supply chain flow: when demand for one sector falls, derived demand falls like dominoes for upstream nodes in the supply chain.

Consider the retail sector in the United States. In January 2009, Circuit City, the second largest consumer electronics retailer in the U.S., announced the closure of all 567 stores. This closure creates 18 million square feet of vacant retail space in an already faltering commercial real estate market. General Growth Properties, one of the largest owners of 200 shopping malls in the U.S., issued a warning in January 2009 that it may seek bankruptcy court protection due to problematic debt payments and carried out the filing in April. The closing of Circuit City alone has caused a reduction in 5 percent to 10 percent advertising revenue for certain newspapers. As a result, many newspapers are cutting back on the news coverage, which causes the readership to decline. Newsstand sales of single-copy magazines such as *Sports Illustrated* and *Cosmopolitan* in the U.S. had already fallen 11 percent in the second half of 2008 from a year earlier so the drop in advertising revenue may push various newspaper and magazine companies over the edge to bankruptcy. On Feb. 23, 2009, the *Wall Street Journal* reported the weekend bankruptcy filings of Philadelphia's two major newspapers and Journal Register Co., publisher of the *New Haven Register* and 19 other dailies. Finally, there is significant loss in account receivables for struggling vendors who supply goods to failed stores.

Consider also that to help the auto industry, the U.S. government is helping out the entire supply chain. On Dec. 19, 2008, the Bush administration announced a short-term loan of $13.4 billion to General Motors to tide it over for a few months. GM then asked the U.S. government to bail out its finance arm, GMAC, and on Dec. 29, 2008, the government approved a short-term loan of $5 billion. On Feb. 4 of this year, 400 auto suppliers, including the giant auto suppliers American Axle and Visteon Corp, asked for $25.5 billion of federal aid because of cash flow problems caused by the delayed payments from the U.S. automakers and asked the government to ensure that payment terms are 10 days rather than the usual 55+ days. Car dealers are also considering requesting federal aid to stay afloat. In late January 2009, two city governments in California approved loans to their local car dealers. Finally, on Feb. 4, the U.S. Senate voted for a tax deduction for sales tax and car loan interest for purchasing a new car under $49,500 between Nov. 12, 2008 and Dec. 31, 2009.

Although any supply chain is in reality an inter-connected network of enterprises without an obvious starting point, it helps to think about it in terms of demand, processing and supply. We can do likewise with the economy or any part of it. To revive the economy, any government should: 1) stimulate demand from consumers, exports and the public sector; 2) improve the economy's processing including financial transactions; and 3) help improve supply by lowering the cost of inputs.

> How should governments develop an integrated set of initiatives as they face a growing number of demands?

1. Stimulate demand. To increase consumer demand, companies offer lower prices. Lowering the value-added-tax (VAT) from 17.5 percent to 15 percent in the United Kingdom amounted to a 2.1 percent price drop for most products and services. However, some retailers have simply maintained the post-VAT price, thus pocketing the reduction rather than passing it on to consumers. Lowering withheld taxes, as effective in the U.S. starting April 1 in accordance with the stimulus package passed in February 2009, also lowers prices as a percentage of disposable income.

Companies can generate new demand for products that are more attractive to end-customers than existing products. For example, U.K. supermarket Tesco's has introduced discount brands to better fit the consumer's recently revised budget. Some businesses have instead increased prices for existing products to compensate for fewer customers, suggesting a short-term outlook.

The government can support companies to meet future demand by supporting

research into new technologies. Both the U.S. and U.K. governments have stated their interest in doing so. These governments can also help companies with retraining of employees in order to meet the changing demand. However, helping sectors continue making products whose underlying demand has fundamentally declined cannot improve economic flows.

As regards the government's demand through public spending, an example is investing in infrastructure. Such investment may not "cost" much if these are projects that the government was going to do so anyway and is only bringing that investment forward. Upgrading the electricity grid in the U.S. as part of a stimulus package is an example. Although public expenses go up, in the long run this may benefit the economy if the infrastructure is truly necessary.

Finally, governments can also seek to enable an increase in exports through export guarantees, especially for medium-sized companies. The U.K. government could extend the existing range of support services to U.K. businesses exporting to other countries through the Export Credits Guarantee Department (ECGD) and the U.K. Trade & Investment. Removing sanctions selectively on countries like Cuba or Iran, while controversial, can also help save jobs in the countries that maintain these sanctions.

2. Improve processing. Based on size, the auto sector and the banking sectors are critical to the U.K. economy. However, from a productivity perspective, the ratio of outputs to inputs for these two sectors are lower than for other sectors in the U.K. such as sporting goods, toys, tobacco products and alcoholic beverages. Providing additional input and support to these two sectors then could generate far less output than if the aid were given to the other sectors. At the very least, the government should impose productivity improvement conditions in bailing out the banking and the auto industry.

In any supply chain, the availability of credit and cash is essential for transactions to take place. However, banks in both the U.S. and the U.K. have created roadblocks for transactions by providing neither credit guarantees for buyers nor adequate lending for working capital for sellers. In the U.K., despite government guarantees to small and medium enterprises to the tune of £1 billion, banks had barely lent 1 percent of that amount as of mid-February 2009.

To get credit flowing, governments may have to break banks up by asset types or to create new institutions altogether. The Royal Bank of Scotland, with the U.K. government as its majority owner, is separating out 20 percent of its assets, so-called toxic ones, this way. More needs to be done to reduce complexity and get credit flowing again regardless of whether large banks in the U.S. and U.K. are nationalized or not. While Prime Minister Gordon Brown has ruled out a "rigid divide" between retail and corporate deposits on one side and international investment banking and trading on the other, he has opened the possibility of the "reinvention of the traditional savings and mortgage bank in Britain." Given the sizes of stimulus packages worldwide, creating new institutions like a World Bank for businesses could also be considered.

3. Improve supply, reduce input costs. There is no shortage of supply given lackluster demand, but input costs could certainly be lower overall. Although prices of oil and many commodities are down, steel prices are beginning to go back up despite low demand from the auto sector. There is also the cost of labor. This is already getting lower, for instance, in the construction sector in the U.K. Governments in the developed world can lower wages, the argument being that a lower-paying job is better than a non-existent one – recall former CEO Lee Iacocca's challenge to the unions to keep Chrysler alive. Countries like France could lower the cost of business by making it easier to hire and fire workers rather than stipulate aid to automakers on the basis of not laying off any workers. Moreover, there is the issue of unemployment benefits: if the difference between wages and unemployment benefits becomes too low, the labor pool may shrink. Thus, lowering wages is tied to lowering unemployment benefits.

Investment in infrastructure can help if it lowers the cost of doing business as part of the input prices. For instance, infrastructure development could help lower costs in countries like China and India; despite a bumper wheat crop this year, prices may not come down too much in India due to poor storage and transportation infrastructure. Indeed, China's $586 billion package announced in November 2008 for housing, infrastructure and post-earthquake reconstruction over two years received warm support from equity markets. However, infrastructure spending may not help much in the United States or in France to reduce costs for businesses unless it is work already planned for the future that will be implemented earlier.

A key input for most businesses is the cost of financing, and governments can help reduce that as we discussed earlier.

Focus on Flow

Stimulating the economic flows along a supply chain without improving the final demand is worse than rearranging the chairs on the deck of the doomed Titanic – there is no benefit despite considerable investment. Some aspects of stimulus packages in western countries could lead to such a situation. For instance, governments could help auto companies make cars that do not find buyers. Banks taking money from the government to improve their balance sheets and to give themselves bonuses, contractual or not, without helping to get economic transactions going again are simply moving the money from government coffers to their own. Retailers who pocket the decrease in VAT-rate reduction in the U.K. similarly defeat the purpose of stimulating consumer demand.

Thus, governments need to look carefully at their plans to see if the benefits might just be one-offs rather than steady improvements to flow in the supply chain all the way from importers through manufacturers and retailers to household consumption or exports. ORMS

ManMohan S. Sodhi *(M.Sodhi@city.ac.uk) heads the Operations Research group at the Cass Business School, City University London, London.*

Christopher S. Tang *(ctang@anderson.ucla.edu) is the Edward Carter Professor of Business Administration at the Anderson School of Business, UCLA, Los Angeles.*

Strong Support for Soft O.R.

The Essence of What Attracted Me to O.R.

To the Editor:

I am somewhat surprised and very disappointed at the response, "Not the Appropriate Outlet," by the editor-in-chief of *Operations Research* to "The Case for Soft O.R." [*OR/MS Today*, Letters to the Editor, April 2009]. The impression I got from reading the response was that if it doesn't contain "rigorous mathematical models," it isn't operations research.

Perhaps we should remember that the field started when it was "operational research" in jolly olde England, or has the field morphed into an erudite, elite domain of mathematicians?

A lot of the early applications did not rely on "rigorous mathematical models," like the flow of vehicular flow through the Holland and Lincoln Tunnels or resource smoothing with Gantt charts. Perhaps these examples are too old, but to me they are the essence of what attracted me to operations research.

I still like the following definition of operations research: "the application of scientific techniques and methods to decision-making problems."

Perhaps what Soft O.R. is – is what O.R. should be.

WILLIAM G. LESSO

William G. Lesso *is professor emeritus of Operations Research and Applied Statistics in the Department of Mechanical Engineering of the University of Texas at Austin.*

Why Settle for Math-for-Tenure Activity?

To the Editor:

The April 2009 issue of *OR/MS Today* brings the usual tide of fine articles and columns, inspiring more than the usual frustration. If I were back in one of Russ Ackoff's classes at the University of Pennsylvania circa 1970 and I handed in this issue as a framing of the issue of how to appeal to practitioners, I would expect to receive an 'F' on problem structuring followed closely by Prof. Ackoff's departure (again) from the OR/MS field.

President Kleinmuntz wonders about our "value proposition" for practitioners ["Value Propositions," President's Desk column, *OR/MS Today,* April 2009]. He cites *Interfaces* and its editorial policy to "improve communications between managers and professionals in OR/MS and to inform the academic community about practice." Think about that wording. The only reference to practice is couched in terms of the academic's desire to learn about it and connect to it; it is not stated in terms of the needs or wants of the practitioner. Imagine if instead the editorial policy was to "improve, increase, demonstrate and document the successful application of OR/MS and to inform the community of keys to success." Is there anyone who would not regard that as different in tone and purpose?

But then what is OR/MS anyway? *Operations Research* Editor-in-Chief Simchi-Levi says his scope covers both methodology and applications, but his objective is "based on rigorous mathematical models and … potential impact on practice." For methodology the mathematics needs to be rigorous and central to the work, but for practice, we will settle not for substantial impact, not for proven impact, not for transferable impact, but for potential impact. Imagine if instead the objective of *Operations Research* or the field or any of the journals in the field was based on "the development of analytic methods that lead to better decisions, having no more and no less complexity than the problems and decisions require, having validity demonstrated by comparing predictions to empirical observations in the classic scientific method, and having relevance to OR/MS demonstrated by evidence of substantive practical value."

I think giants of the field like Churchman and Ackoff would find such a definition something they could work with and a field defined along those lines to be one worth supporting and building. I think the island of Soft O.R. advocates in Europe (whose North American counterparts largely vanished with the first generation of Churchman's and Ackoff's students) might not feel so patronized and rejected with a definition like that. I think the mid-20th century visionaries who created our field out of time-motion studies and military problem-solving would not recognize the math-for-tenure activity we too often settle for (or even set our objectives around).

I think we're not likely to do better at attracting, retaining and involving practitioners until or unless we show we get it.

JOHN R. HALL, JR.
Quincy, Mass.

Pull Its Head Out of the Sand

To the Editor:

April's issue of *ORMS Today* left me increasingly despondent and saddened about the fate of OR/MS in the United States. The reasons have been apparent for years, and are outlined on the last page of John Mingers' excellent piece ("Taming Hard problems with Soft O.R.," *OR/MS Today,* April 2009, p. 48-53) on Soft O.R., paraphrased here:

- For years INFORMS has been controlled by the academic community at the expense of practitioners and broadening the scope of O.R. applications. The top journals have been mathematically oriented to serve the academics' publish or perish regimen.
- The academics stifle, eschew and oppose new, "less pure" approaches, problems and communities.

• In practice, O.R. in the U.S. confines itself to old problems it knows it can solve.

O.R. in the United States had better get its head out of the sand, as the world is leaving it behind. Here's a reality check:

1. Anybody who's been out in the real world for any length of recent time knows that the strictly analytical side of most problems have been solved, and there are numerous tool kits and software applications to solve them. *OR/MS Today* reviews them each year. It takes fewer and fewer people to use these tools, and they don't need to be O.R. types. No growth here.

2. Anybody who's been out in the real world for any length of recent time knows that, since the analytical side has been mostly dealt with, it is the Soft O.R. issues that are coming to the forefront. As former INFORMS President Brenda Dietrich put it, it's time to take the hard, messy problems off the shelf. No growth here for the U.S. Its academically driven society eschews Soft O.R., and the U.S. has conceded leadership to the United Kingdom. Unlike Mingers, I would advise that the U.K. maintain a polite but distant relationship with O.R. in the U.S. and press on developing your own discipline and industry until the U.S. sees the light.

3. There's a whole professional discipline called project management (PM) that could have saved the INFORMS IOL Redesign Team a lot of grief. While PM is a highly developed discipline, there are huge problems in PM that could benefit from years of rigorous analysis coupled with Soft O.R. to provide realistic, institutional models or approaches to solving some of PM's biggest problems; e.g. cost overruns and low estimates of development time and effort. This multidiscipline arena is open for the taking.

4. My guess is the management science guys have left INFORMS for a more receptive organization, and whatever productive advances are being made, are being made outside INFORMS.

5. Lastly, but first for me because I always read "Oracle" first, the O.R. guys are whining about being bullied by MBAs. Gimme a break! If one can't stand up for one's profession in the schoolyard of life, you're probably going to get bullied. This isn't about prejudice; it's about respect. It's about professionalism. The MBAs will stop when you stand up to them and show them what you can do.

If O.R. in the U.S. would take an active leadership role in addressing the modeling of human behavior, adopting Soft O.R. and solving some of the PM problems noted above, it might start to save itself.

RALPH NEBIKER
San Diego, Calif.

EDITOR'S NOTE:

OR/MS Today welcomes letters to the editor on any topic relevant to operations research, management science, *OR/MS Today* or INFORMS. Send letters to Peter Horner, horner@lionhrtpub.com. All letters to the editor are subject to editing for clarity and length. Be sure to include your name, city or town of residence and e-mail.

OPTIMAL or AGILE?

TRADEOFFS BETWEEN OPTIMIZATION AND AGENT-BASED METHODS.

By Wolfgang Ketter and F. Jordan Srour

Imagine working as a dispatcher for a medium-sized freight logistics company. Your day begins by matching a set of orders to a group of drivers. Maybe a computer helps you in this task, but ultimately the outcome is the same – a schedule for the day. This schedule has been carefully constructed to serve all orders at least cost while taking a variety of constraints (e.g. equipment type, time windows, hours of service regulations, etc) into account. Immediately after enacting this plan, changes occur. A truck breaks down, a customer cancels, a load is bigger than expected. The phone starts ringing, and your growing headache reminds you that you should ask your boss for a raise.

The next day you try an experiment. After giving all your drivers cell phones, PDAs, and GPS navigation systems, you tell them to communicate with each other and the customers to create their own schedule. You also make the drivers responsible for negotiating solutions to any troubles encountered en route. In effect, you have rendered your job as a central dispatcher obsolete, leaving more time for other office management tasks. But will the drivers, operating without central knowledge, find the most cost effective route? Which solution will fulfill (or exceed) company goals and objectives?

Images © 2009 JupiterImages Corporation

Will delivery drivers, operating without central knowledge, find the most cost effective route?

These questions are at the heart of the debate between traditional optimization techniques and agent-based modeling (ABM) (also referred to as multi-agent systems [MAS]) [1]. ABM has been lurking on the fringes of the operations research field for some time now. The April 1996 issue of *OR/MS Today,* for example, touts agents as a solution in call center management for Promus Hotel Corporation [2]. Fast forward to February 2005 and ABM is seen emerging as a powerful simulation tool, with roots in the fields of artificial intelligence, social network theory and cognitive science that has grown to encompass techniques in operations research [3]. Most recently in August of 2006, agents appear as a serious and useful simulation technique for a variety of fields [4]. While this depiction throughout the years has exposed the dominating trends in agent research, it has failed to highlight the similarities and differences, strengths and weaknesses of traditional optimization and agent based techniques.

We recently explored the qualitative boundary between O.R. and ABM, in a series of 20 interviews conducted with personnel spanning two continents (North America and Europe) as well as industry and academia. (For a quantitative comparison of a MAS and optimization approach, see, e.g. [5]). The 10 respondents from academia held expertise in artificial intelligence, operations research, computer science, economics and management science. The respondents from industry encompassed problem holders, software developers and solution providers. Through these interviews, we came to the conclusion that the gap between O.R. and ABM is neither as large nor as unbridgeable as the prevailing stereotypes of O.R. and ABM research may indicate.

The primary difference between agents and traditional optimization techniques is the level of control.

Similarities and Differences

THE SIMILARITIES between agents and optimization techniques lay primarily in their goal. The goal of both techniques is to model problems and then advise on decision-making. Furthermore, agents and optimization techniques have uses in the same domains. Just as optimization has its origins in World War II, agents are currently used quite extensively in the defense industry. Dr. V. S. Subrahmanian, a professor in the Department of Computer Science and Director of the Institute for Advanced Computer Studies at the University of Maryland, says that "the success of MAS in the defense field can be measured by increased inquiries and funding from the Department of Defense to academic research groups who develop certain solutions: MAS seems to be quite successful because inquiries and funding are continuing to grow extensively." To further understand the role that both systems can play in one domain, it is necessary to study their differences and subsequently the advantages and disadvantages that these differences bring.

The primary difference between agents and traditional optimization techniques is the level of control – centralized or decentralized. Centralization, as exploited in optimization techniques, can be physically embodied as a person at the center of operations (as was the dispatcher in the opening paragraphs) or virtually present due to high-levels of data aggregation in a central database. Similarly, decentralization, the context in which agents thrive, can also be physical (as in drivers making decisions in the field) or virtual in terms of multiple software components operating autonomously on the same server.

Irrespective of how the level of control is represented, the implications are the same. As one interviewee, Dennis Huisman (Dutch Railways, Edelman award recipient, 2008) put it: "In O.R. methods, everything is connected to everything." A research consultant, Jan Peter Larssen of Almende (a Dutch research company focused on applying multi-agent technolo-

gy), phrased this same concept as "O.R. methods cannot handle locality." Alternately, Tamás Máhr, a researcher also working with Almende, noted that, "basically agents can be used to represent interests. They can be installed at a variety of sites along a supply chain or within a business network."

Given this fundamental difference in the two techniques, what advantages and disadvantages can we extract from the two systems to further the field of informed decision-making?

Advantages and Disadvantages

CENTRALIZATION and the mathematically rigorous techniques of optimization can yield benefits other than just an optimal solution. As Rob Zuidwijk, an associate professor at the Rotterdam School of Management, Erasmus University, noted, looking at a problem in a holistic fashion (as required by optimization techniques) "increases the understanding of the problem...because it requires that the question be well-defined." In a similar vein, Roel van de Vrande, a sales manager at Quyntess, emphasizes that "O.R. systems can be used to offer transparency in decisions." This deep understanding of the problem or transparency of decisions made is not always present in agent-based approaches.

Kafui Monu, a Ph.D. candidate at the University of British Columbia, remarked that "in many cases, computer scientists often lack a framework; they just start programming right away. In contrast, business people and business students, with an economic background, prefer to develop a comprehensive framework that includes all surrounding factors, instead of only looking at the programming code."

The idea that a centralized optimization-based solution to a problem is the optimal solution can, however, be a disadvantage. Pedro Szekely, an assistant professor at the University of Southern California, emphasized that "defining these models is a challenge, and it is always imprecise, or estimates can simply be wrong. Then you end up employing sophisticated algorithms with the wrong numbers." The need for well-calibrated input can be a significant challenge in complex environments. As Bastiaan van de Rakt, a joint owner of INITI8, remarked, "O.R. methods fail in very complex and dynamic (inter) organization structures and are difficult to use for detail-level analysis since the focus is on high level parameters. It doesn't explain events on a small scale." This same concept was eloquently stated by Joost van Dijk of DEAL Services when he said, "O.R. tends to freeze reality."

Aside from the challenges of complexity or dynamism, optimization techniques are often described as unnatural or inappropriate in their handling of the "real-world." This was captured by Jan Peter Larssen of Almende when he said that, "by using O.R. methods, many constraints that are soft in nature, are modeled as being hard constraints, or cannot be modeled at all. This means centralized methods are not really able to work with the real problem. Furthermore, humans cannot work well in cooperation with schedules that are made with O.R. methods, because humans like to take different factors into account as well. For instance: goodwill. Often this is not possible to handle in an O.R. method and therefore a user might not accept the decision of O.R. methods."

To some extent the advantages of a distributed agent system can overcome the disadvantages of optimization-based techniques. A PhD Candidate at the Rotterdam School of Management Erasmus University, Hans Moonen, summarized the advantages of MAS as follows: "There are two main advantages of MAS. The first is its ability to handle dynamism: MAS is able to handle situations where information becomes available at a very late timing. For instance, a sudden change of the entire plan. The second advantage is the MAS offer the ability of negotiating between different stakeholders."

John Collins, a professor in the department of Computer Science at the University of Minnesota, highlighted the first advantage when describing the short decision time of MAS – "Agent systems can be very reactive to new events, whereas O.R. methods may need too much time to recalculate an entire solution when a sudden change occurs."

The second advantage of negotiation is not necessarily unique to agents. What, however, is unique is the way in which agents can negotiate a global solution based on local beliefs using distinctly human tactics. For example, Bastiaan van de Rakt emphasized information hiding as a critical business success factor for MAS – "not all parties in a supply chain are willing to share critical decision information with each other. MAS can support quick decision-making by negotiating a feasible solution to the problem on hand without revealing critical internal information at any moment in time. With a high number of parties involved it is still possible to achieve a solution." These two advantages have led researchers to view agents as a natural metaphor to many real-world dynamic scenarios such as supply-chain management and transportation. This is emphasized by the comments of Peter-Paul van Maanen, a research scientist at TNO. Van Maanen said that "MAS provide a good cognitive model of human societies, and humans can easily understand the role based representation of agents."

> **Not all parties in a supply chain are willing to share critical decision information with each other.**

The advantages of agents do not, however, come without any disadvantages. The biggest disadvantage in MAS is the lack of an optimal solution. As Dennis Huisman put it: "MAS technology usually does not deliver an optimal solution. In fact, when working with MAS you are never sure how optimal its solutions are." This lack of an optimal seems to stem from the uncertainty that pervades MAS. As pointed out by John Collins, "You cannot precisely control what is happening in a MAS, because agents make their own choices at run time. Besides, emergent behavior may occur that is unex-

pected for the business in which the MAS is operating, which could cause troubles."

It appears that this lack of control has hindered the adoption of MAS in industry as noted by our interviewees. MAS has been used successfully in academia for many years now, but in industry it is still not widely used. Luc Scheidel, a principal consultant at Capgemini, reasons that, "It is not proven technology that can be bought off-the-shelf. When you want to use it, companies have to do some more work by themselves. They need the knowledge in order to do that, and experience." This perception was echoed by Haizhen Zhang, a researcher at Microsoft, when he said, "It is hard to actually build a MAS framework; creating the foundations is difficult. Many of those frameworks are developed by different researchers. But it is hard to generalize those formal frameworks into different scenarios for useful applications."

A Hybrid Solution

SO, WHICH APPROACH will meet a company's objectives better? Probably neither. Both systems working in concert have far more potential to solve large-scale business problems than either system working alone. The value of such a hybrid solution can be seen most clearly when dissecting a problem along the three temporal lines of operational, tactical and strategic planning.

As Walther Ploos van Amstel, a member of the board of directors at Versteijnen Logistics, explained: "For tactical applications, it is advised to use O.R. methods. Run O.R. simulations, and then develop 'rules of thumb' for tactical decisions. Considering strategic decisions, such as deciding on which customers a company should focus on, or where a distribution center should be located, O.R. methods are better, too. In both cases this is because of the optimal solutions that it presents. However, for operational decisions, a combination of O.R. and MAS should be employed. O.R. should be used to calculate the preliminary plan, such as the amount of cargo, schedules, etc., using the plan-do-act methodology. After this, MAS can be used for fine-tuning those plans, because of occurring unexpected events. It is impossible to recalculate the entire solution using O.R. methods, and therefore MAS techniques should be used to make dynamic alterations to the plan."

The notion of a hybrid solution is not only an exercise in speculation. For example, The Trading Agent Competition (TAC) [http://tradingagents.org/], an international forum hosting competitions since 2000 to promote and encourage research on trading agents, has seen the emergence of agents that incorporate many optimization-based techniques to help solve their challenging real-time bidding and procurement tasks. In fact, the most successful trading agents adopt and extend state-of-the-art techniques from artificial intelligence, operations research, statistics, and a variety of relevant fields [6]. The hybrid solution was also favored by many of our survey participants, such as by Willem-Jan van Hoeve, assistant professor of Operations Research at the Tepper School of Business of Carnegie Mellon University: "Where O.R. depends on some form of matrix algebra, MAS is able to handle many different forms of mathematical expressions," he says. "But a hybrid approach that combines O.R. and MAS could also be a good solution."

> **Both systems working in concert have far more potential to solve large-scale business problems.**

The emergence of an optimization/MAS hybrid solution in the TAC community and among our interviewees should serve as a harbinger to researchers. The future for both O.R. and MAS lies in the ability of the two methodologies to communicate with each other. There is a need for a more natural and smoother integration of both techniques. How can the handoff from an optimal solution to a MAS implementation be orchestrated? How will the MAS execution affect the optimality of the optimization-based solution? How can the emergent behavior of the MAS be monitored and fed back into the optimization? These are the questions that await a new generation of interdisciplinary researchers. ORMS

Wolfgang Ketter *(WKetter@rsm.nlis) is an assistant professor at the Department of Decision and Information Sciences at the Rotterdam School of Management of the Erasmus University. He founded and runs the Learning Agents Research Group at Erasmus (LARGE).*

F. Jordan Srour *(JSrour@rsm.nl) is a third-year Ph.D. candidate at the Rotterdam School of Management, Erasmus University. Prior to pursuing her Ph.D., she worked as a transportation engineer evaluating new freight technologies at Science Applications International Corporation.*

ACKNOWLEDGMENT

The authors would like to thank all of the researchers for sharing their time and insights with us. We also thank Bas van Dijke, a master's student at the Rotterdam School of Management, Erasmus University, for conducting these interviews as part of his thesis requirement.

REFERENCES

1. M. Wooldridge and N. Jennings, 1995, "Intelligent agents: theory and practice," *Knowledge Engineering Review,* Vol. 10, No. 2, pp. 115–152.
2. D. Blanchard, 1996, "Cutting Edge: Promus Hotel Implements Intelligent Agents," *OR/MS Today,* Vol. 23, No. 2, April 1996.
3. D. Samuelson, 2005, "Agents of Change: How agent-based modeling may transform social science," *OR/MS Today,* Vol. 32, No. 1, February 2005.
4. D. Samuelson and M. Charles, 2006, "Agent-Based Simulation Comes of Age: Software opens up many new areas of application," *OR/MS Today*, Vol. 33, No. 4, August 2006.
5. T. Máhr, J. Srour, M. deWeerdt and R. Zuidwijk, 2008, "Agent performance in vehicle routing when the only thing certain is uncertainty," *Proceedings of Agents in Traffic and Transportation Workshop at 7th International Conference on Autonomous Agents and Multiagent Systems,* May 2008, Estoril, Portugal.
6. W. Ketter, J. Collins, M. Gini, A. Gupta, P. Schrater, 2007, "Pricing and Resource Allocation for Intelligent Trading Agents using Economic Regimes," *Proceedings of 9th International Conference on Electronic Commerce,* Minneapolis, August 2007.

800+

operations
research experts

S T R E N G T H

50

years of
leadership

I N N U M B E R S

possibilities

10 Projects, 10 Lessons

Unexpected, perhaps counter-intuitive results provide priceless experience for simulation consultants.

BY JERRY BANKS
AND
RANDALL R. GIBSON

It is said that experience is the best teacher. We want to share some project experiences that have taught us important lessons over the years. Some projects are recent; others are from years past; in any case the lessons learned are still easily recalled. We can't name the clients involved for reasons that may become obvious to the reader.

In our experience, only a small portion – say 10 percent to 15 percent – of projects produce results that are unexpected, perhaps counter-intuitive and that have a significant impact on the project. But the reason we simulate these systems is that there is no way ahead of time to know which ones will result in these findings. We've chosen 10 projects that produced some of these results.

1. Maintain involvement with the decision-makers throughout the project. We had a most interesting simulation project which involved determining the correct spacing between stations in a distribution center filling orders for cosmetics and related supplies for the women's beauty industry. Orders would arrive from field representatives. These orders were started in one tote on a conveyor that passed by some eight stations each with an array of approximately 50 products that were pulled from "pigeon hole" storage locations and placed in the tote. If and when a tote was filled, but the order had not been completed, another tote was added. So, one order might consist of three totes, for example. The conveyor acted as queueing space for the totes.

We had a great meeting with the manager of the distribution center to start the project. He met our data needs and provided access to his staff. At the halfway mark, we called for the distribution manager so that we could discuss our progress. The response was, "He's not here today." We called again the next day and received the same response. We asked when he would return. We were told, "He's in New York on a special reorganization assignment. He's only here on Fridays." We asked if we could meet on Friday. The answer was, "No, he has a full schedule every Friday that he is here."

We finished the project about two weeks later. We sent the final report to the distribution center manager. We sent an invoice. We were paid. But, we never saw the distribution center manager again

and thus were unable to explain the simulation results. We seriously doubt that our design was ever implemented.

2. Make sure that you know all of the assumptions. One of our largest consulting projects was the redesign of a port and the railroad depot at the port terminal. This port was in Western Australia. The port received iron ore by rail and it was dumped to form two gigantic piles. From these piles, ships bound for Japan were loaded with iron ore according to a recipe.

We were actually sub-contractors on this project. The contractor was a consulting firm that provided service to port operations throughout the world. The contractor was located in the Northeastern United States. The contractor had some simulation capability, but the people there could only model the most basic of systems.

The port in Australia didn't realize at the outset that we were the ones actually building the simulation model. All of our communication went through the contractor, then to the port. This arrangement became cumbersome, so the contractor revealed that we were actually doing the modeling. The port was not upset. In fact, they asked that one of us come to Australia and take a look at the system. After many hours of flying one of us arrived in Sydney, followed by a long flight to Perth in Western Australia. Next there was a two-hour train ride. The port operator insisted that we take a one-hour ride and visit the port. Immediately, we realized there were three gigantic piles, not two. This caused some remodeling activity on our part. We built the model on the wrong assumptions, the assumptions that were provided to us by the intermediary consulting firm.

3. Think outside of the box. A major manufacturer in the Southeastern United States suffered a catastrophe that stopped their production capability. The plant manager of the production facility asked the engineers how long it would take to rebuild the plant. The engineers' response was 18 months.

"I want production in 12 months," said the plant manager.

Eighteen months later, production began, and it built up to normal within two years. The plant made a claim to the insurance company for lost profits. The insurance company said that the reconstruction could have been completed within 12 months and began negotiating with the plant. The plant called on the project management company that had developed an intricate network of activities with time estimates to control the reconstruction. The project management company asked if we could help convince the insurance company of the timeliness of the reconstruction.

Recalling a homework exercise in a simulation book by Alan Pritsker, we built a simulation model that generated a distribution of completion times. Thus, the plant was able to argue that in only a small percentage of the cases could the facility have been rebuilt faster than 12 months.

4. Simulation is an analysis tool, not a design tool. We had a project with a consulting firm in California whose actual client was a manufacturing facility in Ohio. There was a throughput requirement that was set as a goal by the facility in Ohio. We completed our analysis, but reported to the consulting firm in California that the throughput could not be met. They revised the system and sent it back to us. We performed another analysis, but the throughput could not be met by the revised system.

The consulting firm said to us, "If you are so smart, you make it work."

We insisted to the consulting firm that we aren't system designers, but that we had noticed some possible improvements based on our experimentation with the system. We made those changes in the design. Still, the throughput requirements could not be met.

5. Understanding a client's expectations is the first project task; resetting them may be your second task. This problem is something we see often – little or no understanding of simulation. This can lead to unrealistic expectations for the project, expectations that you may not be able to meet. It's critical to test the level of understanding and expectations before you commit to a project. Most decision-makers have simply not come in direct contact with simulation technology before, and they tend to either underestimate or, worse, overestimate what simulation does and what is involved.

In an industrial automation project, the client expected that the model would be able to automatically design an optimal layout and equipment configuration by simply being fed the right data and requirements. When we explained that this is not how simulation models normally work and that this would be very costly, if even possible, they decided they had the wrong consultant! That is, they assumed we did not know what we were doing and informed us that they would look for someone else. We suspect they are either still looking, having been through many consultants who could not deliver on this expectation.

Luckily, we found this out at the beginning of the project rather than after we had spent the time and money to build a model that would never satisfy them.

6. The "perceived" cause and the real cause of a problem can be quite different. The client for this project – a large on-line grocery delivery service in a large metropolitan market – had already completed initial simulation modeling to help design the facility. Orders received via the internet by 11 p.m. were organized, released, picked, packed in the large and highly automated facility and delivered by a fleet of vans according to guaranteed time windows the next day. After two years of operation, the facility appeared to hit a peak throughput at about 50 percent of what the initial simulations said it should be able to achieve. The client had a list of proposed changes which they thought would address the underlying problems: more conveyer accumulation space, additional shipping lanes, changing conveyer diverters, changing the order batching rules – mostly physical changes to address congestion that was easily observed.

The initial model was updated to the "as built" status of the facility, and the proposed changes were added and readied to test before they spent the money on upgrades.

During our data collection activity to confirm the operator productivity rates, we noticed that a lot of "expediting" was going on – people running around to manually complete orders – something that had not been discussed before. After investigating the reason and adding these elements to the model, we were able to demonstrate that most of the congestion, and thus capacity limitation, was due to simple operator pick errors. The client had assumed an accuracy rate that the workforce (which had a very high personnel turnover rate) just didn't achieve. The model clearly showed that pick errors resulted in downstream problems that compounded as the day wore on. The final simulation project results showed the need for very few physical changes, but a new focus on adding automated verification steps for picking, and on recruiting and training to improve operator efficiency and accuracy.

7. The simulation results speak for themselves. As analysts hired to help ensure a successful project, our role is to present the data or simulation results, no matter where they lead. This project, in which we modeled a new, highly automated order picking and packing system for a major shoe distribution facility, almost led to playground behavior. An early modeling phase prior to construction confirmed the operation of the system design, given a series of assumptions at that time.

Sometime after the system went live and showed serious congestion problems, we were asked to come back into the project and update the model to see if we could identify where the problems lay. There were several equipment vendors involved, each with different ideas and stakes in the project. The client, with a very demanding project manager, was withholding payment to everyone until satisfied that the simulation results clearly pointed out what changes were needed, and who would be responsible to implement and pay for them.

Unfortunately, no one was contracted with management or systems integration responsibility, so they all felt that fixing the system should not be their responsibility. When the updated model clearly showed the same problems as the real system, it resulted in serious finger-pointing and yelling and screaming among the team members before order was maintained. We had to be very careful to manage how the data was presented and interpreted.

Working methodically through a series of simulation experiments, we were able to show that no single vendor was significantly at fault, but rather that the problems were the compound result of many factors, not the least of which was that the data the client initially provided for order size and frequency information (profiles) was incorrect. A series of suggested fixes was tested, including showing the effect of increasing the productiv-

ity of the operators, and a solution was finally proposed, proved and successfully implemented.

8. Leave time in the project schedule for the simulation results to have an impact. This project involved a new automated material handling system and control logic to organize, pick, pack and ship orders for a large North American book publisher. Expecting higher throughput to meet projected expansion, the design was based on using a series of horizontal carousels to store the inventory, and conveyers to link the picking stations to each other and to the other processing areas. Several equipment vendors were involved. One contracted us to "verify our design." Assuming that this would be a simple, final step in the design process, we were given only a few weeks to complete it, as "construction of the new system is scheduled to begin very soon."

The results of the simulation clearly showed that the new system would not achieve even half of the total order processing capacity it was required to deliver. We were able to demonstrate that, among other issues, the base problem was related to the order profiles, which were simply not appropriate for this type of automation. The order profiles resulted in many more (largely empty) order totes moving through the system than were expected.

After initial disbelief and challenging of the results, things got interesting. The project was put on hold while the original design firm was challenged to fix the problem. When they were unable to come up with a fix, the design was scrapped and replaced by a completely different approach, requiring many more months to complete than what the original project schedule had allowed.

9. Don't reach too far. Large complex models can become cumbersome and useless. This project, for a major government agency with a large network of facilities, was meant to highlight their new technologies in a showcase facility that was supposed to operate in a "lights out" mode (all manual activities replaced by automation that could run in the dark). The simulation was to be the early centerpiece of promoting the new automated handling and robotic technologies and how they would operate together.

The modeling activity was started before all the major components of the system were well defined or even known. With no ability to see the entire design and start with a simple "top down" approach, we had to start building detailed models for only parts of the facility. This process went on for over a year, taking on one major subsystem after another as they were defined. During this time, we learned a lot about how the system was expected to work. We learned details that were not available at the outset and realized that this would impact the model architecture and underlying assumptions. Each subsystem model had to be connected with the others, resulting in a complex system architecture and database. When all the subsystem models were finally completed and connected, the result was disappointing; a very slow running set of connected models that were difficult to set up and run. Ultimately, the model was set aside and never really met its intended use. We learned a lesson the hard way about understanding the complete modeling requirements first, then properly designing and building the simulation model.

10. Focus on what should be built, not what can be built. We've been involved with a number of projects simulating transportation infrastructure, such as rail switching yards and port intermodal cargo facilities, which can illustrate a different way to employ simulation analysis. In this project, a new rail staging yard near a major port, the objective was to determine which of the alternative layouts would produce the greatest capacity for arriving, staging, inspecting, assembling and departing railcars.

In working through the model requirements with the engineering team designing the rail yard, we found that they were developing several alternate designs to be simulated. These designs attempted to achieve the maximum number and length of tracks that the physical space would allow. We then took a step back to ask what the expected throughput or demand on this facility would likely be, and found that it was less than the total capacity of the final designs. Using the simulation model, we were able to show that the anticipated demand could be met with less infrastructure than the "maximum capacity" design that was being considered.

The simulation results were used to justify a reduced final design, saving the client significant investment for rail infrastructure that would not have been needed. Had we just used the model to answer the question, "Which design has maximum capacity?" we would have missed a key point that the real goal was to answer the question, "Which design best meets the requirements?"

Conclusion

BASEBALL IS OFTEN USED as an analogy to life. It is said in baseball that "sometimes you win, sometimes you lose, and sometimes you are rained out." In providing simulation services, we will say, 85 percent of the time it's something that you have already seen; 10 percent of the time, it's something entirely new; and the remainder of the time things don't go at all as planned. This article talks about some examples in the last two categories. Our problem was not in creating these examples, but in winnowing the list to just 10. ORMS

Jerry Banks *(atljerry@earthlink.net) holds the title Academic Leader at Tecnológico de Monterrey in Monterrey, México. Previously, he retired from the faculty of the School of Industrial and Systems Engineering at Georgia Tech in Atlanta and then he was Senior Simulation Technology Advisor at Brooks Automation (now Applied Materials).*

Randall Gibson *(randall.gibson@me.com) is an independent consultant based in Solana Beach, Calif. Previously, he was Principal and Senior Vice President in the Management and Supply Chain Consulting group at TranSystems Corporation, where he managed the Simulation and Analytical Modeling Practice Area. He was founder and president of Automation Associates, which was acquired by TranSystems in 2005. He has over 20 years experience in simulation modeling and consulting.*

You're there.

You're here, you're there, determining the best course of action based on your business data. JMP® statistical discovery software lets you model, predict and decide your next move with confidence. JMP is visual business analytics from SAS, the trusted choice of 91 of the top 100 companies on the 2008 FORTUNE Global 500® list.

www.jmp.com/analytics

celebrating 20 years

jmp®
Statistical Discovery.™ From SAS.

OPPORTUNITIES ABOUND FOR O.R. IN THE INTERPLAY BETWEEN MEDICINE, BIOENGINEERING AND MEDICAL PHYSICS.

Computational Biology and Medical Applications

By
Harvey J. Greenberg, Allen G. Holder,
Ming-Ying Leung and Russell Schwartz

In recent years the frontiers of biological and medical research have become increasingly dependent on sophisticated modeling, analysis and computational techniques. Operations research (O.R.) and computer science (CS) have emerged as vital tools for investigating complex biological systems. The interaction between O.R. and biomedicine has been fruitful and synergistic. In turn, the biomedical research has spawned new mathematical developments in O.R. and its interfaces with CS.

In fall 2007 the *INFORMS Journal on Computing* initiated the Area of Computational Biology and Medical Applications to recognize the role of O.R. in this exciting frontier and to attract new researchers who can contribute to this revolution. While much could be said, this article is intended to give a brief account of how O.R. is already becoming critical to biomedical research and where we believe great opportunities exist for new contributions and contributors. Our hope is that you, the reader, will see the merit in joining us in this enterprise. We encourage those applying O.R. to biomedicine, whether established practitioners or new contributors, to consider *JoC* as an outlet for publishing results. Although there are dozens of journals already publishing O.R. applied to this area, not all of them recognize that they are using O.R. and will generally not bring their work to the attention of the broader O.R. community.

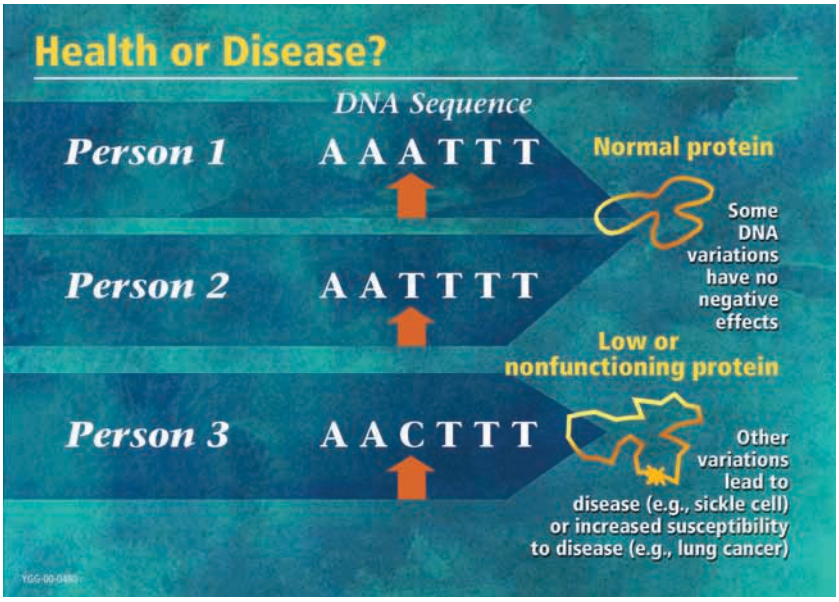


Figure 1. Variations in the DNA sequences of different people can lead to altered structure or expression of proteins, influencing disease risk. Source: U.S. Department of Energy Genome Programs (http://genomics.energy.gov).

A primary aim of the *JoC* Area's research is to help scientists reach more accurate conclusions more quickly and reliably. That is where the modeling and solution techniques of O.R. combine with the algorithm and interface designs of CS. Working in the O.R. tradition of a team effort, we get results. Have a look at recent publications that illustrate a broader spectrum of interests, such as the *JoC* special issue in 2004 (16:4) and the special issue of *Annals of Operations Research* in 2006 (148:1). The following sections give a brief introduction to some opportunities for O.R. in biology and medicine.

O.R. in Healthcare and Medicine

THERE IS A RICH HISTORY of applying O.R. to problems in healthcare and medicine. See Brandeau et al. [1] for a modern review and Ozcan [10] for an instructional text. The tradition within healthcare is to use O.R. to support operational and managerial decisions, and this is where the history is most steeped. However, advanced medical technologies and greater sophistication in their use has led to numerous medical procedures that have lent themselves to O.R. Many of these include the interplay between medicine, bio-engineering and medical physics. We discuss the popular topic of optimizing radiotherapy treatments to develop the general theme of applying O.R. and computing to medical procedures. See Ehrgott et al. [5] for a comprehensive review.

The fundamental premise behind medical applications is to provide a quality of care within the confines of the application, and the optimal design of a radiotherapy treatment is like any other O.R. application from this overarching perspective. A brief look at the clinical practice is important to understand the multiple ways O.R. is involved. Patient images are used to locate targets and to identify nearby tissues that should not receive high amounts of radiation, called organs at risk. Tissues are delineated on a sequence of 2D images to create a 3D rendering of the segmented anatomy. An oncologist prescribes radiation goals for the targets and upper bounds for the organs at risk, as well as other prescription information. This is used to design a treatment that is typically delivered in daily fractions over a period of a few weeks.

There are two places where O.R. plays a role prior to treatment design. First, the disease is commonly viewed through different images, each of which presents different aspects of the disease. Ideally, images are fused via an optimal process so that physicians can better assess the disease's state. Second, the lengthy delineation process that identifies anatomical structures is an image segmentation problem, and such problems have previously benefited from O.R. methods of optimization and modeling. This process is currently managed manually but could benefit significantly from automation, raising many opportunities in the O.R./CS interface.

The 3D partition of the anatomy and the prescription information are used to design a patient-specific treatment. Treatment design is divided into three phases, each of which is associated with an optimization process. The first phase is to select the pathways (beams) through the anatomy along which the radiation will be delivered. Although many commercial systems allow this to be automated, these methods are generally not trusted and are typically ignored. Instead, beams are manually selected with

Figure 2: Modern technology, such as the radiotherapy treatment system depicted, supports increasingly complicated medical procedures that benefit from sophisticated O.R. and computing to harness the technology's capabilities. Source: Medicalphysicsweb (http://medicalphysicsweb.org).

sophisticated imaging software. The second phase calculates the amount of radiation, called "fluence," that is to be delivered along each of the selected beams. This problem is solved by an optimization algorithm, although models and solution methods vary among commercial systems. The third phase decides how to deliver the treatment as well as possible. This is automated, but not optimized, in all commercial systems.

Clinical practice dictates a trial-and-error technique in many cases. A designer selects beams, optimizes fluence and evaluates the computed treatment. Evaluation often indicates the possibility of improvement, and the designer re-selects beams and repeats the process until satisfaction is reached. The final treatment then undergoes the third phase, which sequences delivery. Each of the phases has been studied as an optimization problem, and the current trend is to tie them together in hopes of optimizing the totality of the design. However, this goal is challenged by many modeling and solving issues, not the least of which is the fact that clinical optimality is not well defined. The individual studies of each phase have positioned the field to address optimizing the coupled processes, and a systematic comparison of the combinations supported by the literature is needed. This is a significant computational challenge, one for which the O.R. community is exceptionally well qualified.

Although our discussion has specifically addressed optimizing radiotherapy treatments, the basic themes canvass many medical procedures. Indeed, nearly any technique that is tailored to meet the needs of a specific patient and/or clinic has an underlying design to optimize. Examples outside medical physics include the design of prosthetics, robotic surgery, rehabilitation and the optimal scheduling of vaccines, to name a few. There are also examples in diagnostics, with one of the most well known being the use of separating hyperplanes to distinguish between disease and non-disease or between clinically important sub-types of common diseases. New applications in medicine often require multi-disciplinary research interests since the problems span modeling, solving and analysis. Moreover, harnessing modern clinical technologies and methodologies relies on our ability to compute solutions efficiently and to provide computer-assisted analysis of results.

O.R. in Genomics

JUST AS O.R. HAS PROVEN ITS VALUE in applied medical contexts, it is likewise emerging as a crucial component of basic research in modern biology. One especially important application area is the study of genetic variations, which are the small differences that distinguish the genome of any one person from any other. Since the landmark production of the first human genome sequences, much attention in human genomics has turned to identifying how individual people differ from these canonical (consensus) genomes across human populations.

Genetic variations predominantly take the form of single nucleotide polymorphisms (SNPs), which are single DNA bases with two common forms in the genome, of which several million have now been identified. Other differences between our genomes consist of structural variations, in which large pieces of DNA are duplicated, deleted or rearranged in some people relative to others. It has only recently become apparent that these structural variations are far more common than was previously suspected and account for a large part of the genetic variation within our species.

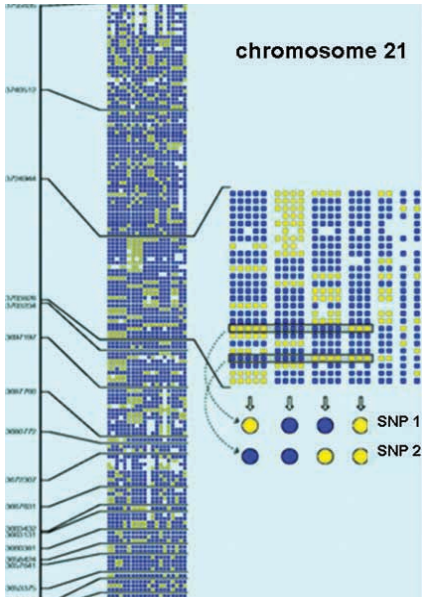


Figure 3: SNPs genotyped from 20 chromosomes across a region of chromosome 21, with the inset revealing their organization into a few common haplotypes across individuals. Source: Science, Vol. 294, No. 5,547, pp. 1,719-1,723.

Several major initiatives are now underway, such as the International Haplotype Map (see www.hapmap.org) and the 1,000 Genomes Project (see www.1000genomes.org), to further catalog the millions of common human genetic variants and to determine how they are distributed within thousands of individual people and across dozens of human populations. The product of these initiatives is a vast and rapidly growing set of data that needs to be analyzed to identify new variations, to perform basic research into our history as a species, to better characterize the functions and evolution of our genes, and to apply the results to improving human health. These problems depend on advances in computational methods for analyzing large genomic data sets, an area presenting many opportunities for O.R.

One area in which O.R. methods have already proven valuable is in solving new computational problems arising from modern genome sequence determination. Shotgun sequencing – the technology used by Celera Genomics in generating one of the two initial consensus human genome sequences and now the preferred method for all large sequencing projects – depends on solving a large-scale graph optimization problem (a variant of the traveling salesman problem) to assemble a genome from millions of small fragments.

Most of our DNA, though, comes in the forms of pairs of chromosomes with one copy of each inherited from the mother and from the father. Genome sequencers from the Venter Institute have only recently determined the first diploid human genome, separating the contributions of the two slightly different copies of each chromosome in a single individual. The problem of reliably reconstructing the two chromosome copies, known as *haplotype assembly* or *diploid assembly,* has likewise attracted interest in the O.R. community, but many problems – i.e., opportunities – remain.

The large amounts of genomic variation data becoming available have also revived some "solved" problems from the much older field of phylogenetics (the inference of evolutionary trees). Even the simplest versions of phylogenetics are formally computationally intractable. While practical heuristics

have done well with smaller datasets, they are poorly suited to the genome-scale datasets becoming available. Traditional O.R. optimization techniques, such as branch-and-bound methods, have a long history in this field, and more advanced methods are now being applied to solve increasingly harder problem instances.

In addition, the availability of genome-scale variation data has given new importance to solving challenging variants of the phylogeny problem. For example, the mixture of densely packed variants and large genomic distances makes it essential to incorporate into phylogenetic models a process called recombination, in which chromosomes evolve in part by swapping genetic material with one another. The resulting problem of inferring *phylogenetic networks with recombination,* as opposed to the more traditional *phylogenetic trees,* remains unsolvable in practice. As more sophisticated models of molecular evolution are developed, to account for our greater knowledge of genome variation and how it evolves, there will almost surely be a need for more sophisticated optimization methods to make practical use of these models in phylogenetic applications.

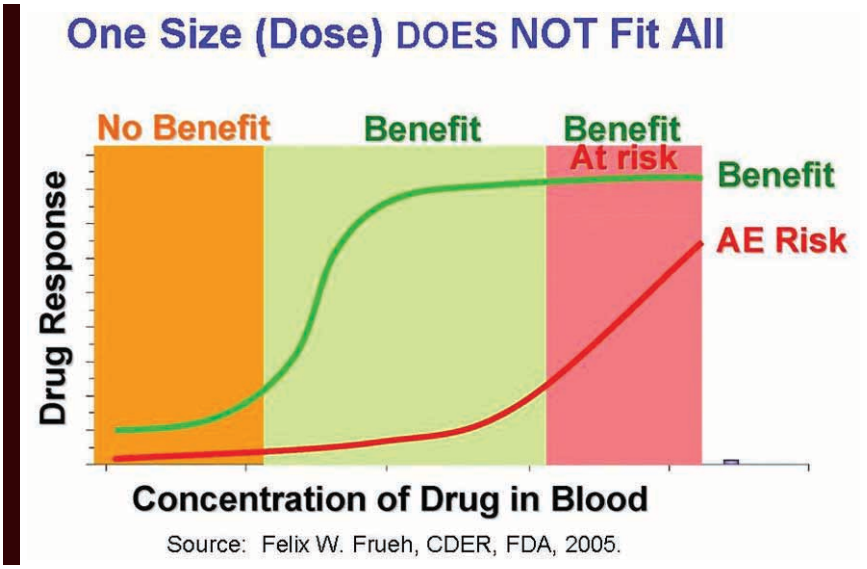


Figure 4: Many drugs are effective due to a therapeutic advantage, shown in the figure as the difference between the curves. The therapeutic advantage varies between individuals and between strains of the disease. Source: Felix W. Frueh, CDER, FDA, 2005.

An emerging area for O.R. in genomics is the use of optimization and simulation methods to apply knowledge of genetic variation to the diagnosis and treatment of disease. Work in characterizing genetic variation is largely motivated by the hope of finding genetic variants that are statistically associated with disease, which in turn will help us develop diagnostic tests or identify genes that may be targets for drugs. O.R. methods have begun to be used to assist in mining genomic variation datasets for often weak evidence of association with disease, but much remains to be done. A central goal of the genetic variation studies is *personalized medicine* – the idea that a patient's treatment is specific to his/her DNA. This is already happening, revolutionizing clinical practice by enabling doctors to shift from diagnostic and remedial to predictive and preventive medicine.

One of the many important effects is bringing more drugs to patients by stratifying the clinical trials, using DNA properties to separate those who benefit from the drug from those who would be harmed. Not only does this provide better treatment to more patients, but it also lowers the cost of each drug since more enter the market. (It costs about $1.4 billion and 12-15 years to bring a drug to market, starting with 10,000 prospects. If two of the prospects get through clinical trials due to stratified testing, that cost can be split between the prices of two drugs, rather than covered by the one drug that makes it.)

While the biological knowledge needed to make personalized medicine a reality is now becoming available, the computational infrastructure does not yet exist. There are significant opportunities for O.R. practitioners familiar with similar decision analysis problems to determine how to guide the design of the clinical trials and how to productively put this decision-making power into the hands of medical doctors in clinical practice.

Members of the O.R. community interested in learning more might consult any of a number of recent sources on genome variation and related computational problems. An overview from a computer science perspective of many of the classic computational problems in genome assembly and analysis is given by Gusfield [7]. Felsenstein [6] provides a more detailed summary of the specific issue of phylogenetics and some of the complications in practical phylogeny inference. More recent computational problems in genetic variation analysis were surveyed by Halldórsson et al. [8] One may also refer to Pennisi et al. [12] for a survey aimed at the general scientist on the biological basis of genetic variation studies and their medical importance, with many helpful links to other resources and seminal studies in the area.

Stochastic Models

STOCHASTIC MODELS, notably Markov chains, have formed one of the foundations for computational biology and related medical applications. DNA, RNA and amino acid sequences resemble juxtapositions of random and non-random letter sequences from a finite alphabet. It is a generally accepted premise that nucleotide- and amino acid-base sequences at the biologically important sites, which are associated with structural conservation, functional significance or evolutionary relations, have characteristics distinct from random letter sequences. In order to help identify unusual patterns within a single sequence or significant similarities among multiple sequences that might have biological relevance, real data sequences are often compared with random letter sequence models.

DNA and RNA nucleotide-base sequences are most often compared to random sequences generated from a four-letter alphabet representing the four nucleotides. The amino acid sequence for proteins is from a 20-letter alphabet representing

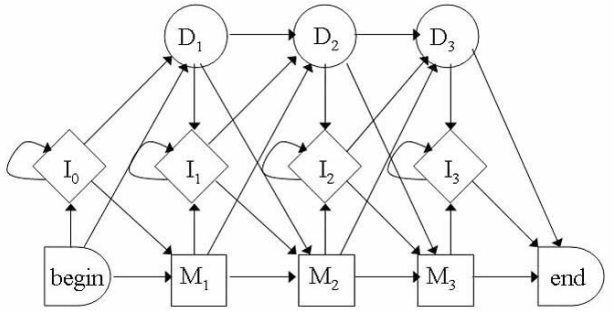


Figure 5: Hidden Markov model for a DNA sequence motif allowing for insertions and deletions in a three-base consensus sequence. Source: H.J. Greenberg course notes, 2003, based on [4].

the 20 distinct amino acid residues. Sequence models based on alternative alphabets reflecting the physical and chemical properties of the nucleic acids and amino acids (e.g., strengths of the hydrogen bonds between complementary nucleotides, the electrostatic charges on the amino acids) are also used. In the simplest case, the models are represented as a sequence of independent and identically distributed random variables. In more sophisticated representations, these are Markov-type models, including higher order and hidden Markov chains.

From these random sequence models, general scoring schemes and assessment methods for statistical significance of molecular sequence features are derived. In particular, the limit distribution of the maximal non-aligned two-sequence segmental score has served as the statistical foundation for the widely used BLAST software [9] for molecular sequence database searching.

Many other applications of Markov chain sequence models use information about short strings of letters, called *words,* in the sequences. For an alphabet of size *s,* there are s^k distinct words of length *k.* The underlying Markov model provides a theoretical framework for deriving occurrence frequencies and distributions of various individual words or groups of words with a special pattern. For example, the palindrome pattern in DNA and RNA, which is involved in molecular binding and folding activities, has been studied for a variety of biological problems including gene expression and regulation, viral genome replication, etc. While specific investigations differ, we note that they often reduce to a problem of finding suitable statistical distributions, such as the Poisson and normal types of distributions, to approximate the behavior of the random variables or random processes of interest. The book by Deonier et al. [2] gives an excellent introduction to the analysis of word distribution and occurrences and their applications in DNA mapping and signal recognition.

Although obtaining nucleotide and amino acid sequences has become routine, capturing the variation of the functional characteristics at different parts of the sequence is not always straightforward. For example, it is generally difficult to distinguish whether a DNA segment codes for a protein or not, or whether or not an amino acid sequence segment belongs to a DNA binding domain. These problems have motivated the use of hidden Markov models [4] in which the functional states are typically hidden, and the chain of observable emitted symbols is the nucleotide or amino acid sequence itself. Profile hidden Markov models for sequence families have also been applied successfully to obtain optimal and suboptimal sequence alignments that are useful for predicting protein structures or inferring phylogenetic relationships.

In order to understand the functions of cells, tissues, organs, etc., from the analysis of the basic biomolecules like DNA, RNA and proteins, one needs to know what genes are expressed under different physiological conditions. With the development of microarray technology (see [3, Chapter 11] for a brief introduction) during the past two decades, expression levels of thousands of genes can be measured simultaneously, thus creating the possibilities of investigating and comparing entire genomes or proteomes. These studies have contributed greatly to recent biomedical advances in cancer and pharmaceutical research, and they have spurred the development of a myriad of new statistical and computational tools to deal with high-dimensional data with large numbers of variables but small sample sizes. Among these, Bayesian modeling and inference, data-mining techniques like classification and clustering, as well as optimization-based machine learning techniques, such as support vector machines, are popular approaches.

Microarray technology has empowered scientists to acquire extensive information on gene activities with relative ease. However, the genes on the DNA and the proteins they code for do not work independently, but rather in highly dynamic and interactive genetic and biochemical networks. Among various stochastic models used in modeling complex genetic regulatory networks, the probabilistic Boolean network has probably received the most attention. In this model, the state (on or off) of a gene is represented by a Boolean variable and the interactions among genes are represented by Boolean functions. The biological basis for such a formulation rests in the observation that during regulation of functional states, the cell exhibits switch-like behavior. This allows coarse-grained properties of large genetic networks and interactions of genes to be studied with limited quantitative biochemical details. Steady-state behavior of probabilistic Boolean network models and the effect of perturbations can be studied as optimal control problems in the framework of Markov chains [3].

A classical text is by Waterman [13], and a more recent one is by Wilkinson [14]. Those working in stochastic processes will find familiar foundations for applications to computational biology.

Systems Biology

THE BIOSCIENCE COMMUNITY has started taking a systems approach to account for interactions among many components in a biological system; such interactions are often modeled as networks – see Palsson [11] for a comprehensive introduction. The systems approach is ready for new O.R. applications, bringing to bear decades of work on network flows, combinatorial optimization and dealing with uncertainty.

Two primary types of systems are *cell-signaling* and *metabolic* pathways. A signaling molecule, like a hormone, sends a

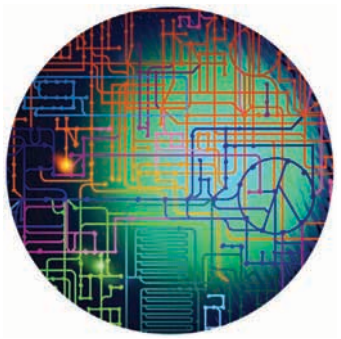


Figure 6: Systems biology uses networks to explain the complex behavior exhibited by cellular processes. Source: U.S. Department of Energy Genome Programs (http://genomics.energy.gov).

signal to a receptor by converting one physical or chemical form of the signal to another (called signal transduction). For example, signaling often works through cascades of phosphorylation, in which the signal is transmitted by special proteins called kinases that attach phosphate groups to their targets, altering their behavior. These targets may themselves be kinases activated by the phosphates to phosphorylate further targets, transmitting and amplifying a signal until it results in some functional change. There are many reasons for signaling, including programmed cell death. Regulation is another, and mixed-integer programming models have proven valuable to infer optimal pathway properties, such as one of minimum length to produce some particular metabolite. We may also want to block a pathway while minimizing "side effects," such as not blocking other pathways.

Metabolic pathways use enzymes (proteins that catalyze the reaction) to convert metabolites (small organic compounds). These are like factories and come in different varieties. *Science Daily* [Aug 16, 2006] reports:

> *Toxoplasma gondii is one nasty bug. A microscopic parasite, it lives in the intestinal tract of cats but can be carried by most warm-blooded animals. In humans, it can harm or even kill a developing fetus, and it can as well sicken those with compromised immune systems, such as AIDS patients. Now, for the first time, cellular biologists at the University of Georgia and the University of Pennsylvania have shown that fatty acid synthesis in T. gondii is essential for the parasite's survival. The discovery could lead to the development of new drugs to make the parasite's effects much less troublesome in both humans and animals.*

O.R. contributes to the analysis of extreme pathways, using linear programming for the steady-state stoichiometric equation, $Sv = 0$, where S is an mxn matrix whose coefficients describe the rate of each of m metabolites used or produced in each of n reactions, and v is the flux. Extreme rays of the polyhedral cone reveal how pathways are composed and combined. Further, there are different normalizations for v and several objectives. For the human mitochondria, objectives include ATP production, heme biosynthesis and mixed phospholipid biosynthesis. This field has been benefitting from O.R. models, ranging from linear programming to multiple, nonlinear objectives and binary variables.

Databases and software have only recently been developed to catalog and annotate the pathways. Kinetics, from estimated reaction rates, are fundamental for modeling the behavior of complicated networks for applications such as drug design. Standard models and theory from O.R., such as continuous-time Markov models and queueing theory, are (under-) used to understand them, yet they have become central to the simulation of complicated reaction networks. Add artificial intelligence methods, such as reasoning about missing (unknown) parts of a pathway, and we have an O.R. arsenal of models, methods, and analysis techniques. Indeed, the O.R. community is ready to contribute to breakthroughs, and you can be part of that. ORMS

REFERENCES

1. M. Brandeau, F. Sainfort, and W. Pierskalla, editors, 2004, "Operations Research and Health Care: A Handbook of Methods and Applications," Kluwer Academic Publishers, Norwell, Mass.
2. R. C. Deonier, S. Tavare, and M.S. Waterman, 2005, "Computational Genome Analysis: An Introduction," Springer, New York, N.Y.
3. R. Dougherty, I. Shmulevich, J. Chen, and Z.J. Wang, 2005, "Genomic Signal Processing and Statistics," Hindawi, New York, N.Y.
4. R. Durbin, S. Eddy, A. Krogh, and G. Mitchison, 1998, "Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids," Cambridge University Press, Cambridge, Mass.
5. M. Ehrgott, C. Güler, H. Hamacher, and L. Shao, 2008, "Mathematical optimization in intensity modulated radiation therapy, *4OR – A Quarterly Journal of Operations Research,* Vol. 6, No. 3, pp., 199-262.
6. J. Felsenstein, 2004, "Inferring Phylogenies," Sinauer and Associates, Sunderland, Mass.
7. D. Gus?eld, 1997, "Algorithms on Strings, Trees and Sequences," Cambridge University Press, Cambridge, U.K.
8. B. Halldórsson, V. Bafna, N. Edwards, R. Lippert, S. Yooseph, and S. Istrail, 2003, "Combinatorial problems arising in SNP and haplotype analysis," in C. Calude, M. J. Dinneen, and V. Vajnovszki, editors, "Discrete Mathematics and Theoretical Computer Science, Proceedings of the 4th International Conference" (LNCS 2731), Springer-Verlag, Berlin/Heidelberg, pp. 26–47.
9. S. Karlin and S. F. Altschul, 1990, "Methods for assessing the statistical significance of molecular sequence features by using general scoring schemes," *Proceedings of the National Academy of Science,* Vol. 87, No. 6, pp. 2,264-2,268.
10. Y. Ozcan, 2005, "Quantitative Methods in Health Care Management: Techniques and Applications," Jossey-Bass/Wiley, San Francisco, Calif.
11. B. Ø. Palsson, 2006, "Systems Biology: Properties of Reconstructed Networks," Cambridge University Press, New York, N.Y.
12. E. Pennisi, 2007, "Breakthrough of the year: Human genetic variation," *Science,* Vol. 318(5858), pp. 1,842–1,843.
13. M. S. Waterman, 1995, "Introduction to Computational Biology: Maps, Sequences and Genomes," Chapman & Hall/CRC, Boca Raton, Fla.
14. D. Wilkinson, 2006, "Stochastic Modeling for Systems Biology," Chapman &/CRC, Boca Raton, Fla.

Harvey Greenberg *(hjgreenberg@gmail.com) is professor emeritus of Mathematical and Statistical Sciences at the University of Colorado Denver and the founding editor of the* INFORMS Journal on Computing.

Allen Holder *is an associate professor of Mathematics at the Rose-Hulman Institute of Technology and area editor of Computational Biology and Medical Applications for the* INFORMS Journal on Computing.

Ming-Ying Leung *is a professor of Mathematical Sciences and director of the Bioinformatics Program at The University of Texas at El Paso and associate editor for Computational Biology and Medical Applications for the* INFORMS Journal on Computing.

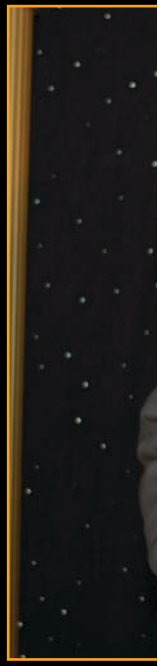
Russell Schwartz *is an associate professor of Biological Sciences at Carnegie Mellon University and associate editor for Computational Biology and Medical Applications for the* INFORMS Journal on Computing.

Less is More for HP

By Peter Horner

Hewlett-Packard earns coveted practice prize by transforming management of massive product portfolio.

They say that variety is the spice of life, but don't tell that to Hewlett-Packard, whose abundance of product variety bumped up revenues but also gave the world's largest technology company a serious case of indigestion that ultimately and negatively impacted its bottom line. The cure: operations research.



HP's ground-breaking use of O.R. not only enabled the high-tech giant to successfully transform its product portfolio program and return $500 million over a three-year period to the bottom line, it also earned HP the coveted 2009 Edelman Award from INFORMS for outstanding achievement in operations research. The announcement of the award winner, capping a day-long competition in which six finalists from around the world made a series of presentations before a panel of judges, was delivered in dramatic fashion by INFORMS President Don Kleinmuntz at the 2009 INFORMS Practice Conference in Phoenix. Robert Bixby served as master of ceremonies for the Oscars-like Edelman Awards gala.

"This is not the success of just one person or one team," said Kathy Chou, vice president of worldwide commercial sales at HP, in accepting the award on behalf of the winning team. "It's the success of many people across HP who made this a reality, beginning several years ago with mathematics and imagination and what it might do for HP."

To put HP's product portfolio problem into perspective, consider these numbers: HP generates more than $135 billion annually from cus-

Opposite page:
Hewlett-Packard VP Kathy Chou (front, center) and other members of the Edelman Award-winning team have plenty to smile about after capturing the "Super Bowl of O.R."

Below:
Hewlett-Packard VP Kathy Chou receives Edelman Award from INFORMS President Don Kleinmuntz.

Edelman: The Final Six

Led by Kathy Chou, vice president of worldwide commercial sales at Hewlett-Packard, the 2009 Edelman Award-winning team included Ann Brecht, Brian Cargille, Russ Chadinha, Gavin DeNyse, Shailendra Jain, Holger Mishal, Thomas Olavson, Cookie Padovani, Kurt Sunderbruch, Robert Tarjan, Julie Ward, Joseph Woods, Bin Zhang of HP; Jason Amaral of Emeraldwise LLC; Dirk Beyer of M-Factor; Chris Fry of Strategic Management Solutions; Qi Feng of the University of Texas at Austin; Sesh Raj of DSApps, Inc.; Krishna Venkatraman of Intuit; and Jing Zhou of the University of North Carolina at Charlotte. Their presentation was entitled, "HP Transforms Product Portfolio Management with Operations Research."

OTHER FINALISTS INCLUDED:

CSX TRANSPORTATION
for "CSX RAILWAY CASHES IN ON OPTIMIZED EQUIPMENT DISTRIBUTION."

CSX used math modeling to create a system for assigning and repositioning empty cars. The company claims approximately $2 billion total savings from car mileage reductions, car management workforce reduction and capital avoidance, and notes other qualitative benefits of the system to the public.

IBM
for "OPERATIONS RESEARCH IMPROVES SALES PRODUCTIVITY AT IBM."

IBM used operations research to help the company identify new sales opportunities and to better allocate sales resources to the best future revenue-generating accounts.

MARRIOTT INTERNATIONAL
for the "GROUP PRICING OPTIMIZER."

The company's operations research-aided system empowers the sales team with the information they need to profitably negotiate the price of proposed group bookings. The system automates a complex manual process to maximize revenue, hotel profitability and the quality of time spent taking care of customers. Since its implementation GPO has been used to contract over $1 billion in group business.

NORSKE SKOG
for "NORSKE SKOG IMPROVES GLOBAL PROFITABILITY USING O.R."

The publication paper industry has faced declining markets and margins for several years. The Norwegian-based company, with plants in 12 countries on four continents, used operations research to downsize and reduce manufacturing and supply chain costs, potentially $120 million per annum (~3% of turnover). Thanks to robust analysis, tough decisions were made and implemented with minimal disruption.

ZARA
for "ZARA USES OPERATIONS RESEARCH TO REENGINEER ITS GLOBAL DISTRIBUTION PROCESS."

The Spanish clothing manufacturer and retailer, which achieves Fast Fashion by making millions of shipments a week to stores from its central warehouses, used operations research to optimize its distribution process and increase in-season sales by an estimated 3 percent to 4 percent – in excess of $230 million in 2007 and $350 million in 2008.

The 'Super Bowl of O.R.'

Named in honor of a pioneer of O.R. practice at the RCA Corporation, the Franz Edelman Award for Achievement in Operations Research is considered the "Super Bowl of O.R" because it honors the best applications of operations research in the world. The nearly eight-month competition begins with a call for nominees in the fall. The nominees are asked to provide a two-page summary of a practical application of O.R. that has had a significant, positive impact on the company's operations and bottom line. A team of verifiers is then sent forth to make on-site visits to learn more about the nominated work and verify claims made in the application process.

The field of nominees is gradually narrowed down until six finalists are invited to present their cases before a panel of judges at the INFORMS Practice Conference in the spring.

2009 Edelman Committee Chair Srinivas Bollapragada of General Electric served as one of the judges, along with Peter Bell of the University of Western Ontario, Terry Harrison of Penn State University, Russ Labe of Merrill Lynch, Patricia Neri of Southwest Airlines, Leon Schwartz of Yeshiva University, Donald (Bob) Smith of Monmouth University, ManMohan Sodhi of City University London and Mike Trick of Carnegie Mellon University. INFORMS

tomers in 170 countries by offering tens of thousands of products supported by the largest supply chain in the industry. You want variety? How about 2,000 laser printers and more than 20,000 enterprise servers and storage products. Want more? HP offers more than eight million configure-to-order combinations in its notebook and desktop product line alone.

The something-for-everyone approach drives sales, but at what cost? At what point does the price of designing, manufacturing and introducing yet another new product, feature or option exceed the additional revenue it is likely to generate? Just as important, what are the costs associated with too much or too little inventory for such a product, not to mention additional supply chain complexity, and how does all of that impact customer satisfaction?

According to Chou, HP didn't have good answers to any of those questions before the Edelman award-winning work.

"While revenue grew year over year, our profits were eroded due to unplanned operational costs," Chou said in HP's formal Edelman presentation. "As product variety grew, our forecasting accuracy suffered, and we ended up with excesses of some products and shortages of others. Our suppliers suffered due to our inventory issues and product design changes. I can personally testify to the pain our customers experienced because of these availability challenges."

Chou would know. In her role as VP of worldwide commercial sales, she's "responsible and on the hook" for driving sales, margins and operational efficiency.

Constantly growing product variety to meet increasing customer needs was the HP way – after all, the company is nothing if not innovative – but the rising costs and inefficiency associated with managing millions of products and configurations "took their toll," Chou said, "and we had no idea how to solve it."

Compounding the problem, Chou added, was HP's "organizational divide." Marketing and sales always wanted more – more SKUs, more features, more configurations – and for good reason. Providing every possible product choice was considered an obvious way to satisfy more customers and generate more sales.

Supply chain, on the other hand, always wanted less. Less to forecast, less inventory, less complexity to manage. "The drivers (on the supply chain side) were cost control," Chou said. "Supply chain wanted fast and predictable order cycle times. With no fact-based, data-driven tools, decision-making between different parts of the organization was time-consuming and complex due to these differing goals and objectives."

By 2004, HP's average order cycle times in North America were nearly twice that of its competition, making it tough for the company to be competitive despite its large variety of products. Extensive variety, once considered a plus, had become a liability.

It was then that the Edelman prize-winning team – drawn from various quarters both within the organization (HP Business Groups, HP Labs and HP Strategic Planning and Modeling) and out (individuals from a handful of consultancies and universities) and armed with O.R. thinking and methodology – went to work on the problem. Over the next few years, the team: 1) produced an analytically driven process for evaluating new products for introduction, 2) created a tool for prioritizing existing products in a portfolio, and 3) developed an algorithm that solves the problem many times faster than previous technologies, thereby advancing the theory and practice of network optimization.

The team tackled the product variety problem from two angles: pre-launch and post-launch.

"Before we bring a new product, feature or option to market, we want to evaluate return on investment in order to drive the right investment decisions and maximize profits," Chou said. To do that, HP's Strategic Planning and Modeling Team (SPaM) developed "complexity return on investment screening calculators" that took into account downstream impacts across the HP product line and supply chain that were never properly accounted for before.

Once a product is launched, variety product management shifts from screening to managing a product portfolio as sales data becomes available. To do that, the Edelman-award winning team developed a tool called revenue coverage optimization (RCO) to analyze more systematically the importance of each new feature or option in the context of the overall portfolio.

The RCO algorithm and the complexity ROI calculators helped HP improve its operational focus on key products, while simultaneously reducing the complexity of its product

offerings for customers. For example, HP implemented the RCO algorithm to rank its Personal Systems Group offerings based on the interrelationship between products and orders. It then identified the "core offering," which is composed of the most critical products in each region. This core offering represented about 30 percent of the ranked product portfolio. All other products were classified as HP's "extended offering."

Based on these findings, HP adjusted its service level for each class of products. Core offering products are now stocked in higher inventory levels and are made available with shorter lead times, and extended offering products are offered with longer lead times and are either stocked at lower levels or not at all. The net result: lower costs, higher margins and improved customer service. (Detailed technical accounts of the HP Edelman-winning work, as well as the work of all of the other 2009 Edelman finalists, are scheduled to appear in an upcoming issue of *Interfaces*.)

The RCO software algorithm was developed as part of HP Labs' "analytics" theme, which applies mathematics and scientific methodologies to help decision-making and create better-run businesses. Analytics is one of eight major research themes of HP Labs, which last year refocused its efforts to address the most complex challenges facing technology customers in the next decade.

"Smart application of analytics is becoming increasingly important to businesses, especially in the areas of operational efficiency, risk management and resource planning," says Jaap Suermondt, director, Business Optimization Lab, HP Labs. "The RCO algorithm is a fantastic example of an innovation that helps drive efficiency with our businesses and our customers."

In accepting the Edelman Award, Chou emphasized not only the company-wide effort in developing elegant technical solutions to incredibly complex problems, but also the buy-in and cooperation of managers and C-level executives and the wisdom and insight of the award-winning team to engage and share their vision with those managers and executives.

"For some of you who have not been a part of a very large organization like HP, this might sound strange, but it required tenacity and skill to bring about major changes in the processes of a company of HP's size," Chou said. "In many of our business [units], project managers took the tools and turned them into new processes and programs that fundamentally changed the way HP manages its product portfolios and bridged the organizational divide."

By most accounts, the 2009 Edelman event was perhaps the most competitive in its 38-year history, with CSX Transportation, IBM, Marriott International, Norway's Norske Skog and Spain's Zara (see box) all providing first-class presentations. When asked what put HP over the top with the judges, Randy

Robinson, a former executive director of INFORMS and Edelman Committee member and frequent Edelman coach who served as one of the coaches of this year's HP team, offered this:

"Certainly the impact of the work on HP was substantial and pervasive. Secondly, they had great teamwork. They were able to handle the trouble that you so often see in a big company with different departments and competing interests. They had the magic to overcome those obstacles and get people to work together. They received enthusiastic support from all levels of the company, including senior management. Third and perhaps most important, the technical work was outstanding. It was practical, but part of it involved cutting-edge advances and methods. I think all of that combined to set them apart from some very tough competition."

HP's Chou, who congratulated the other finalists in her acceptance remarks, later said "that just being a part of the Edelman Awards has really raised the visibility of operations research at HP. We've seen tremendous improvements thus far, but after this, I will personally make sure that O.R. becomes the foundation of any major process improvement going forward. This project has taken us to the next level. What has really come through is senior management's involvement and the understanding of how important O.R. is … to how we do business in the future in a much more sophisticated and higher impact way."

That message is already clear based on the comments of Shane Robison, executive VP and chief strategy and technology officer at HP. "Innovation is the lifeblood of our company," he said via video as part of HP's Edelman presentation. "We believe continuous innovation is just as vital to our business processes as it is to our products and services. Our work in operations research is relevant to both areas and critical to retaining a competitive edge in the marketplace." ORMS

Peter Horner *(horner@lionhrtpub.com) is the editor of* OR/MS Today *and* Analytics. ***Barry List*** *(barr.list@informs.org), the director of communications for INFORMS, contributed to this article. More information about the Edelman competition can be found online at www.scienceofbetter.org/Edelman .*

Intel Wins INFORMS Prize

Karl Kempf (left), head of the Intel Decision Technology Group, accepts INFORMS Prize from committee chair Rangananth Nuggehalli.

While the Edelman Award each year honors an outstanding example of operations research practice, the INFORMS Prize salutes organizations for "sustained integration of operations research." The INFORMS Prize Committee looks for a variety of applications of O.R. in a single organization that provides the organization with a competitive advantage through high-impact work. The committee is particularly impressed with organizations that "repeatedly apply O.R. in pioneering, varied, novel and lasting ways."

Rangananth Nuggehalli of UPS, the INFORMS Prize Committee Chair, presented the award to Intel at the gala held in conjunction with the INFORMS Practice Conference in Phoenix.

Nuggehalli recognized Intel's demonstrated record of using operations research throughout the company's strategic, tactical and operational levels. "The Prize committee's task was challenging, and the quality of all the submissions we considered was high," said Nuggehalli, adding that Intel showed how companies could drive significant value and competitive advantage by utilizing O.R. throughout an organization.

According to Intel Chairman Craig Barrett, the operations research group at Intel has contributed constantly and over an important period of time. "Semiconductors are among the most complex things that man has ever made," he said.

For the past two decades, Intel's decision technology group has worked behind the scenes to provide sound recommendations for designing factories, improving manufacturing, making accurate sales forecasts and prioritizing the features that should be introduced during new product development, he said.

"They have literally saved Intel billions of dollars," Barrett said.

Barrett was joined by Karl Kempf, who leads the Intel Decision Technology Group.

The award committee found that Intel had an impressive track record applying operations research methods throughout the many distinctive business areas at the company.

The 2009 INFORMS Prize Committee cited the Intel Decision Technologies Group for putting O.R. inside every facet of Intel's business. "By employing an extensive array of operation research disciplines and an innovative process to diffuse them, the Decision Technologies Group impacted a vast and diverse set of Intel's functions such as product design, demand forecasting, factory development, pricing structures, equipment and material acquisition and production/inventory/logistics planning," the citation continued. "From tactical manufacturing operations to strategic roadmap development, the myriad of operations research applications contributed more than $2 billion in improved decision-making. Intel demonstrated the effectiveness of O.R. techniques by continuing to produce better products at lower prices year after year."

Intel Chairman Craig Barrett says the company's O.R group has "literally saved Intel billions of dollars."

The Daniel H. Wagner Prize for Excellence in Operations Research, awarded to John Neal and Sean Willems of Boston University for their paper, "Managing Inventory in Supply Chains with Nonstationary Demand," was also recognized at the gala. ORMS

INFORMing the globe

Register Today!

INFORMS
Annual Meeting
San Diego 2009
October 11-14, 2009

technology

biotech

health care

environment

San Diego

ORGANIZING COMMITTEE

General Chair
Soheila Jorjani
California State University San Marcos
sjorjani@csusm.edu

Program Co-Chairs
Mohammad Oskoorouchi
California State University San Marcos
moskooro@csusm.edu

Carlton Scott
University of California Irvine
chscott@uci.edu

Invited Sessions Chair
Thomas Roemer
University of California San Diego

Tutorials Chair
Mohammad Oskoorouchi
California State University San Marcos

Sponsored Sessions Chair
Robert Aboolian
California State University San Marcos

Contributed Sessions Chair
Abdullah Dasci
York University

Administrative Chair
Fred Raafat
San Diego State University

Arrangements Chair
Jeffery Guyse
Cal. State Polytechnic University-Pomona

Practice Program Chair
Ishpal Rekhi
Hewlett Packard

THANKS TO OUR SPONSORS

ILOG An IBM Company

AIMMS 3

UTD School of Management
The University of Texas at Dallas

SOFTWARE SURVEY

Tenth in a series of LP surveys reveals solution methods continue to be refined for speed and reliability.

Image © 2009 JupiterImages Corporation

By Robert Fourer

LINEAR PROGRAMMING

This is the tenth in a series of surveys of software for linear programming, dating back to 1990. As in the case of earlier surveys, information has been gathered by means of a questionnaire sent to software vendors by *OR/MS Today*. Results are summarized by product in the tables following this article. Contact vendors for further details.

Products listed in this survey are concerned, at the least, with minimizing or maximizing linear constraints subject to linear equalities and inequalities in numerical decision variables. All products provide for continuous variables that may take any values between their bounds, and many also accommodate integer variables that are limited to whole-number values in some way. The respectively continuous and discrete problems that use these variables are commonly distinguished as linear programs (LPs) and integer or mixed-integer linear programs (IPs/ILPs or MIPs/MILPs), but for convenience "LP software" is used herein as a general term for the packages covered, and "LP" refers to problems that may or may not have some integer variables.

Some of the listed products handle other kinds of discrete variables and constraints, as well as varied nonlinearities and even problems outside of optimization. This survey focuses on developments and trends in the linear programming and related integer programming aspects of the software, however. Also, the listing excludes products that address only certain applications or formulations of LP, or that are not targeted to large LP instances, as these products are more properly evaluated in the context of other broad categories of optimization software. The ordering of topics below is roughly parallel to the organization of the tables, and terms in bold correspond to table headings.

The printed table is limited to responses available by press time, but additional responses are welcome and will be added to the Web version of the survey. To learn more, write to Online Projects Manager Patton McGinley, patton@lionhrtpub.com, or go directly to the survey at www.lionhrtpub.com/ancill/lpsurvey2009.shtml.

Types of Packages

ALTHOUGH THE PRODUCTS surveyed have a common purpose and share many aspects of design, they are best understood as incorporating two complementary but fundamentally different types of software. **Solver** software takes an instance of an LP model as input, applies one or more solution methods and returns the results. **Modeling** software does not incorporate solution methods; it is typically designed around a computer modeling language for expressing LP models, and offers features for reporting, model management and application development, in addition to a translator for the language.

Numerous solver and modeling products have been developed as independent applications. Thus, solvers typically support **links to** many modeling systems, and modeling systems offer **links to** many solvers. In some cases the two may be acquired as separate products and linked by the purchaser, but more commonly they are bought in bundles of various kinds. Most modeling system developers arrange to offer a variety of bundled solvers, providing modelers with an easy way to benchmark competing solvers before committing to purchase one. Some solver developers also offer bundles with modeling systems. A number of the latter developers also offer **integrated** systems that provide a modeling environment specifically for their own solvers. Many variations on these arrangements are possible, so prospective purchasers are well advised to confirm the details carefully.

Interfaces to Other Software

SINCE OPTIMIZATION MODELS are usually developed in the context of some larger algorithmic scheme or application (or both), the ability of LP software to be embedded is often a key consideration. Thus, although virtually any of the listed products can be run as an **independent application** in some kind of stand-alone mode, many are available in **callable library** form, often accessible as **class libraries** in an object-oriented framework. Solver systems have long been available in these ways, with an application-specific calling program taking

the place of a general-purpose modeling environment. Modeling systems have increasingly also become available for embedding so that the considerable advantages of developing and maintaining a modeling language formulation can be carried over into application software that solves instances of a model. It is possible to embed an entire modeling system, or a particular model or an instance of a model; not all systems provide all possibilities, so some study is necessary to determine which products are right for a given project in this respect.

Most commercial LP software libraries are distributed as binaries for linking into the user's applications. In addition, our table includes several non-commercial solvers that make their **source code a**vailable, often through one of the standard open source licenses (www.opensource.org). Open source is ideal in situations where the greatest degree of flexibility is required, such as in creating new algorithms and algorithmic schemes, or in putting together specialized application packages that require optimization problems to be solved internally at numerous points. But where the emphasis is on building models, solving instances and analyzing results, it makes more sense to use software that someone else has gone to the trouble of compiling. Even some of the open-source solvers offer binaries for the more popular platforms.

The application development environments provided by **spreadsheet** and **database** programs have proved to be particularly attractive for embedding of LP software. At the least, most LP modeling environments can read and write common spreadsheet and database file formats. Spreadsheet packages can also accept solver add-ins whose appeal to users and convenience for development are widely appreciated. The solver add-in that comes packaged with Excel is effective only for small and easy problems; independent developers offer much more powerful spreadsheet options. Some can work with a variety of spreadsheet functions that go beyond the smooth arithmetic functions assumed by classical optimization software. Several scientific and statistical packages also offer LP software add-ins specifically for their products; MATLAB appears to be the most popular in this respect.

Virtually all LP modeling systems and solvers can also handle model instances expressed in simple text formats, especially the "MPS" format dating back many decades and various "LP" formats that resemble textbook examples complete with + and = signs. These formats mainly serve for submitting bug reports and for communicating benchmark problems. Modeling systems use much more general and efficient formats for communicating problem instances to solvers and for retrieving results. Each uses its own format, unfortunately, so that every modeler-solver link requires a different translation. There is continuing interest in a superior standard form that could express problem instances of more kinds, in ways that would help to integrate LP software with Web communication standards like XML. Progress has been gradual, however, and no definitive standard form can be said to be adopted as yet.

Platforms

THE RANGE OF SUPPORTED PLATFORMS continues to be stable. **Windows** remains universal, and **Linux** has become nearly so for products other than spreadsheet add-ins. Among other Unix variants, Solaris, HP-UX and AIX are still quite common. Support for Apple computers has increased substantially, though primarily through ports to the Unix shell of MacOS System X, rather than through the creation of new versions that conform to a more standard Macintosh look and feel.

Multiprocessor versions for **shared memory** have become widely available, as multicore processor architectures have become the standard and two quad-core processors have become a readily obtained configuration on high-end PCs. Support for **distributed memory** remains relatively rare, despite continued general interest in "grid computing" and networks of workstations. Distributed processing seems a natural fit for integer programming branch-and-bound methods, which solve independent subproblems at nodes of a huge search tree, but promising experiments with this approach do not seem to have led yet to much commercial support.

Most LP software takes advantage of all **available memory,** and so most packages have been ported to the **64-bit** processors that are necessary for effective support of multiple gigabytes of physical RAM. In the case of MIP solvers, the ability to take advantage of **available disk space** to store part of the search tree is also valuable.

Trials

SIZE-LIMITED **DEMO** VERSIONS (also often called student versions) permit experimentation with small problem instances. They are typically full-featured versions of the software, limited only by being restricted to problem instances of up to a few hundred variables and constraints. Several modeling systems offer conveniently packaged demo versions with one or more solvers.

Most modeling language and solver developers will arrange to provide full versions of their software for testing for a limited time. A number of developers also make their products conveniently available for testing and comparison over the Internet, via the **NEOS Server** (neos.mcs.anl.gov). NEOS imposes no problem size restrictions and is free of charge. It does not guarantee confidentiality or availability of service, but those may not be the key issues in initial stages of testing.

Prices

THE TABLE SHOWS individual commercial licenses running from under $500 to as much as $5,000, but many vendors quote prices only on request. Special terms are often available for multiple purchases and for **site licenses** or **floating licenses** (which permit a certain number of copies to be used anywhere in a large network). Since solver performance varies considerably from problem to problem and from product to product, buyers are well advised to benchmark problems of interest before deciding which products are likely to offer the best value.

Algorithms

SOLUTION METHODS have continued to be refined for speed and reliability. For linear programs a choice between **primal simplex, dual simplex** and **interior-point** methods is standard. The bag of tricks that make up the typical MIP

Linear Programming, *continued on p.54*

SOFTWARE PRODUCT LISTING

	Software Description								Platforms Supported												Size of Problem Solvable by This System											
	Type				Form				PC/ Windows		PC/ Linux		Other Unix-based		Other				Multiprocessor Support (list platforms)		Largest Version Limited By:				Demo/Student Version							
	Solver	Modeling Environment	Integrated Solver and Modeling Environment	Independent Application	Procedure/Callable Library	Object/Class Library	Source Code	Add-in To:	32-bit	64-bit	32-bit	64-bit	32-bit	64-bit	Specify	32-bit	64-bit	Specify	Shared Memory	Distributed Memory	Internal Restrictions	Max # of Constraints	Available Memory	Available Disk Space	Processor Architecture	Constraints	Variables	Integer Variables	Nonzeroes	Free or Open-Source	Free NEOS Server Access
AIMMS, the modeling system *Paragon Decision Technology Inc.*	–	y	y	y	y	y	–	Excel, Web Services, C/C++, RPC, and more	y	y	y	y	–	–	–	–	–	–	Parallel Solver Sessions (Windows /Linux)	–	–	–	y	y	y	300	300	300	No restriction	–	–
AMPL *AMPL Optimization LLC*	–	y	–	y	–	–	–	–	y	y	y	y	y	y	Solaris, Mac OSX, AIX, HP-UX, IRIX	–	–	–	–	–	–	–	y	y	y	300	300	300	–	–	y
AMPL COM *Optirisk Systems*	–	y	y	–	y	y	–	Any COM compatible calling application	y	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	y	1,000	1,000	150	1M	–	–
AMPL Studio *Optirisk Systems*	–	y	y	y	–	–	–	–	y	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	y	1,000	1,000	150	1M	–	–
BendX Stochastic Solver *Maximal Software, Inc.*	y	–	–	–	y	y	–	MPL Mod. Sys., CPLEX, GUROBI, CoinMP	y	y	y	y	y	y	Sun Solaris, HP-UX, AIX	–	–	–	–	–	–	Unlmtd.	y	y	–	500	500	500	Unlmtd.	y	–
C-WHIZ *Ketron Optimization*	y	–	–	y	–	–	–	–	y	y	y	–	–	–	–	–	–	–	–	–	–	–	y	–	–	32,767	–	–	–	–	–
CBC *COIN-OR*	y	–	–	y	y	y	y	–	y	y	y	y	y	y	AIX, Solaris	–	–	Can be ported to most systems	Linux, Unix, Windows (needs pthreads)	–	–	–	y	–	y	–	–	–	–	y	y
CLP *COIN-OR*	y	–	–	y	y	y	y	–	y	y	y	y	y	y	AIX, Solaris	–	–	Can be ported to most systems	–	–	–	–	y	–	y	–	–	–	–	y	y
CoinMP *Maximal Software, Inc.*	y	–	–	–	y	y	y	MPL Modeling System, Others	y	y	y	y	–	–	Solaris, Mac OSX	–	–	–	–	–	–	Unlmtd.	y	y	–	–	–	–	–	y	–
DATAFORM *Ketron Optimization*	–	y	–	y	–	–	–	–	y	y	y	–	–	–	–	–	–	–	–	–	–	–	–	y	–	–	–	–	–	–	–
flopc++ *COIN-OR*	–	y	–	–	–	y	y	flopc++	y	y	y	y	y	y	–	–	–	–	–	–	–	–	y	–	–	–	–	–	–	y	–
FortMP *Optirisk Systems*	y	–	–	y	y	–	–	–	y	–	y	–	y	–	Solaris	–	–	–	–	–	–	–	y	y	y	1,000	1,000	150	1M	–	–
FortMP - API *Optirisk Systems*	y	–	–	y	y	–	–	MATLAB, S Plus, R	y	–	y	–	y	–	Solaris	–	–	–	–	–	y	1M	y	–	y	1,000	1,000	150	1M	–	–
FortSP *Optirisk Systems*	y	–	–	y	y	–	–	–	y	–	–	–	–	–	Solaris	–	–	–	–	–	y	1M	y	–	y	1,000	1,000	150	1M	–	–
GAMS *GAMS Development Corporation*	y	y	y	y	–	–	–	–	y	y	y	y	y	y	SPARC Solarix, Intel Solaris, AIX, et. al.	–	–	–	by solver	–	–	–	y	y	y	300	300	50	2,000	–	y

	Pricing Information									Data Compatibility					Solvers or Modeling Environments			Formulations Supported												Algorithms															New Features
	Commercial			Educational			Demo/Student											Variable Types (in addition to linear)				Constraint & Objective Types (in addition to linear)					Linear Programming				Integer Prog. (in addition to branch-and-bound)					Utility								
	Single machine	Floating licenses available	Site licenses available	Single machine	Floating licenses available	Site licenses available	Single machine	Floating licenses available	Site licenses available	Reads Spreadsheets	Writes Spreadsheets	Reads Databases	Writes Databases	Reads and Writes Text	Solvers/Model Environments that Link to this Product	Bundled as a Single Pckg.	Available Separately	Integer, Binary	Semi-continuous	Arbitrary Discrete (SOS1)	Piecewise Linear (SOS2)	Other	Convex Quadratic Objective	2nd-Order Cone Constraints	General Convex	General Nonlinear	Other	Primal Simplex-based	Dual Simplex-based	Interior Point	Branch-and-cut	Branch-and-price	Heuristics for Seeking Feasible Solutions	Other	Presolve	Infeasibility Diagnosis	Other							
	$1,800	y	y	$100	y	y	Free	y	y	y	y	y	y	CPLEX, GUROBI, XPRESS, etc. Open Solver	y	y	y	y	y	y	–	y	–	y	y	Indicator constraints, lazy constraints	y	y	y	y	–	y	GMP Library to structure/create own, AOA	y	y	Graphical Mathematical Program Inspector							Non-Linear math¿Program Inspector, Solution pooling, Lazy constraints, Benders decomposition algorithm (open), and more.
	$4,000	y	–	$400	y	–	Free	–	–	y	y	y	y	y	35+ solvers listed on Website	y	y	y	y	y	y	–	y	–	y	y	Complimentary, logical	–	–	–	–	–	–	–	y	–	–								Solver support for multiple solutions, parameter tuning, local search, mixed-integer programming with nonlinearities
	Contact	y	y	Contact	y	y	Contact	y	y	y	y	y	y	y	FortMP, MOPS, CPLEX, full list on Website	–	y	y	y	y	y	–	y	y	y	y	Complimentary, logical, general nonlinear	–	–	–	–	–	–	–	–	–	–								Complementarity constraints; "lazy" constraints and user cuts; indicator (logic) constraints; global optimization solver support.
	Contact	y	y	Contact	y	y	Free	y	y	y	y	y	y	y	FortMP, MOPS, CPLEX, full list on Website	y	y	y	y	y	y	–	y	y	y	y	Complimentary, logical, general nonlinear	–	–	–	–	–	–	–	–	–	–								Complementarity constraints; "lazy" constraints and user cuts; indicator (logic) constraints; global optimization solver support.
	Contact	y	y	Contact	y	y	Free	y	y	–	–	–	–	–	MPL Modeling System, CPLEX, etc.	y	y	–	–	–	–	–	–	–	–	–	–	y	y	y	–	–	–	Benders, DEQ	y	–	–								BendX offers unique object-oriented library stochastic interface for Visual Basic, C#, and Java on top of the standard C-API callable library.
	$1,800 - $3,100	y	–	$360 - $620	y	–	–	–	–	y	y	y	y	y	DATAFORM	y	y	y	y	y	y	–	–	–	–	–	–	y	y	–	–	–	–	–	y	–	MATEDIT, matrix; SOLVIEW, solution								–
	Open Source code - free for all uses	–	–	–	–	–	–	–	–	–	–	–	–	y	–	–	–	y	y	y	y	Lotsizing plus user written	–	–	–	–	–	y	y	y	y	–	y	–	y	–	–								–
	Open Source code - free for all uses	–	–	–	–	–	–	–	–	–	–	–	–	y	CBC, SCIP, Symphony plus many more	y	–	–	–	–	–	–	–	–	–	–	–	y	y	y	–	–	–	–	y	–	–								–
	Free	–	–	Free	–	–	Free	–	–	–	–	–	–	–	MPL Modeling System	y	y	y	y	y	y	–	–	–	–	–	–	y	y		y	–	y	–	y	–	–								New release offers object-oriented library interfaces for Visual Basic, C#, and Java. Linux/UNIX versions available w/automake/configure sup.
	$2,400	y	–	$480	y	–	–	–	–	y	y	y	y	y	C-WHIZ	y	y	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	MATEDIT, matrix; SOLVIEW, solution; etc.								–
	Free	–	–	–	–	–	–	–	–	–	–	–	–	–	CBC, CLP, CPLEX, DyLP, FortMP, etc.	y	y	y	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–								–
	Contact	y	y	Contact	y	y	Free	y	y	–	–	–	–	y	AMPL, AMPL Studio	y	y	y	y	y	y	–	y	y	–	–	–	y	y	y	y	–	y	–	y	y	–								Second order cone constraints support.
	Contact	y	y	Contact	y	y	Contact	y	y	y	y	y	y	y	MATLAB, S Plus, R	–	y	y	y	y	y	–	y	y	–	–	–	y	y	y	y	–	–	–	y	–	–								Easy connection scripts for SPlus and R now available, as well as the already available MEX file for Matlab.
	Contact	y	y	Contact	y	y	Contact	y	y	–	–	–	–	–	SPInE	–	y	–	–	–	–	Problem with recourse	–	–	–	–	Chance and integrated chance	–	–	–	–	–	–	Level decomposition w/ regularization, etc.	–	–	–								Level decomposition; callable library implementation; (Intgrtd.) Chance Constraints support; selectable LP solver subsystem.
	Visit Website	y	y	Visit Website	y	y	Free	y	y	y	y	y	y	y	ALPHAECP, BARON, many others	y	y	y	y	y	y	–	y	y	y	y	Mixed integer nonlinear, mixed compl.	y	y	y	y	y	y	–	y	y	–								See http://www.gams.com/docs/release/release.htm

SOFTWARE PRODUCT LISTING

	Software Description								Platforms Supported												Size of Problem Solvable by This System									
	Type				Form				PC/ Windows		PC/ Linux		Other Unix-based		Other		Multiprocessor Support (list platforms)				Largest Version Limited By:				Demo/Student Version					
	Solver	Modeling Environment	Integrated Solver and Modeling Environment	Independent Application	Procedure/Callable Library	Object/Class Library	Source Code	Add-in To:	32-bit	64-bit	32-bit	64-bit	32-bit	64-bit	32-bit	64-bit	Specify	32-bit	64-bit	Specify	Shared Memory	Distributed Memory	Internal Restrictions	Max # of Constraints	Available Memory	Available Disk Space	Processor Architecture	Constraints	Variables	Integer Variables	Nonzeroes	Free or Open-Source	Free NEOS Server Access
GIPALS - Linear Programming Environment *Optimalon Software*	y	y	y	y	–	–	–	–	y	y	–	–	–	–	–	–	–	–	–	–	–	–	–	y	–	–	1,000	1,000	–	–	–	–
GIPALS32 - Linear Programming Library *Optimalon Software*	y	–	–	–	y	y	–	–	y	y	–	–	–	–	–	–	–	–	–	–	–	–	–	y	–	–	1,000	1,000	–	–	–	–
GLPK (GNU Linear Programming Kit) *Free Software Foundation, Inc.*	y	y	y	y	y	–	y	–	y	y	y	y	y	y	–	–	y	MMIX Donald Knuth's 64-bit RISC	–	–	–	–	–	y	–	y	–	–	–	–	y	y
GUROBI *Gurobi Optimization, Inc.*	y	–	–	y	y	y	–	EXCEL, MATLAB	y	y	y	y	–	–	–	–	–	–	–	–	All supported platforms	–	–	–	y	y	–	500	500	–	–	–	–
IBM ILOG CPLEX *ILOG, an IBM Company*	y	–	–	y	y	y	–	–	y	y	y	y	y	y	AIX, HP-UX, Solaris	y	y	MacOS	All supported platforms	–	–	–	–	–	y	–	–	–	–	–	–	–
IBM ILOG OPL Development Studio *IBM*	–	–	y	y	–	–	–	–	y	y	y	y	–	–	AIX, Solaris	–	–	–	All supported platforms	–	–	–	–	y	–	–	500	500	–	–	–	–
KNITRO Solver 6.0 *Ziena Optimization, Inc.*	y	–	–	–	y	–	–	AIMMS, AMPL, Excel, Frontline, GAMS, et. al.	y	y	y	y	y	–	Mac OSX	–	–	–	–	–	–	–	–	y	–	–	300	300	–	–	–	y
Lamps *Advanced Mathematical Software Ltd*	y	y	y	–	y	y	–	–	y	–	–	–	–	–	–	–	–	–	–	–	–	–	y	64K	y	y	–	N/A	N/A	N/A	N/A	–	–
LINDO API *LINDO Systems, Inc.*	y	–	–	–	y	–	–	–	y	y	y	y	y	y	32 and 64-bit Solaris, Mac PPC and x86	–	–	–	–	–	–	–	–	y	–	–	250	500	50	Unre-stricted	–	–
LINGO *LINDO Systems, Inc.*	–	–	y	y	y	–	–	Excel	y	y	y	y	–	–	–	–	–	–	–	–	–	–	–	y	–	–	250	500	50	Unre-stricted	–	–
LOQO *Princeton University*	y	–	–	y	y	–	–	AMPL, GAMS	y	y	y	y	y	y	–	–	–	–	–	–	–	–	–	y	y	–	300	300	0	90,000	–	y
MPL Modeling System *Maximal Software, Inc.*	–	y	y	y	–	–	–	CPLEX, GUROBI, XPRESS, XA, MOPS, LINDO, et. al.	y	y	y	y	y	y	Sun Solaris, HP-UX, AIX	–	–	–	Windows, LINUX, UNIX	–	–	Unlmtd.	y	y	–	500	500	500	Unlmtd.	y	–
OML (Optimization and Modeling Library) *Ketron Optimization*	–	–	y	–	y	–	–	–	y	y	y	–	–	–	–	–	–	–	–	–	–	–	–	y	y	–	32,767	–	–	–	–	–
OMP Plus *OM Partners*	y	y	y	y	y	–	–	–	y	y	–	–	–	–	–	–	–	–	–	–	Win32, Win64	–	–	y	y	y	500	500	500	Unlmtd.	–	–
OptiMax Component Library *Maximal Software, Inc.*	–	y	y	–	y	y	–	CPLEX, GUROBI, XPRESS, XA, MOPS, LINDO, et. al.	y	y	y	y	y	y	Sun Solaris, HP-UX, AIX	–	–	–	Windows, LINUX, UNIX	–	–	Unlmtd.	y	y	–	500	500	500	Unlmtd.	y	–

	Pricing Information									Data Compatibility				Solvers or Modeling Environments			Formulations Supported										Algorithms											New Features
	Commercial			Educational			Demo/Student										Variable Types (in addition to linear)				Constraint & Objective Types (in addition to linear)					Linear Programming			Integer Prog. (in addition to branch-and-bound)				Utility				
	Single machine	Floating licenses available	Site licenses available	Single machine	Floating licenses available	Site licenses available	Single machine	Floating licenses available	Site licenses available	Reads Spreadsheets	Writes Spreadsheets	Reads Databases	Writes Databases	Reads and Writes Text	Solvers/Model Environments that Link to this Product	Bundled as a Single Pckg.	Available Separately	Integer, Binary	Semi-continuous	Arbitrary Discrete (SOS1)	Piecewise Linear (SOS2)	Other	Convex Quadratic Objective	2nd-Order Cone Constraints	General Convex	General Nonlinear	Other	Primal Simplex-based	Dual Simplex-based	Interior Point	Branch-and-cut	Branch-and-price	Heuristics for Seeking Feasible Solutions	Other	Presolve	Infeasibility Diagnosis	Other	
	$297	y	–	$150	–	–	$0	–	–	y	y	–	–	y	–	–	–	–	–	–	–	–	–	–	–	–	–	–	y	–	–	y	–	y	–	–	Improved preprocessor and speed of the calculation.
	$249	y	y	$125	y	y	$0	–	–	–	–	–	–	y	–	–	–	–	–	–	–	–	–	–	–	–	–	–	y	–	–	y	–	y	y	–	Improved preprocessor. Added support for FORTRAN and VB.Net.
	–	–	–	–	–	–	–	–	–	–	–	y	y	y	–	–	–	y	–	–	–	–	–	–	–	–	–	y	y	y	y	–	y	–	y	–	–	–
	See website	y	y	$100-$850 depending on options	y	y	Free restricted version available	–	–	–	–	–	–	–	AIMMS, AMPL, FRONTLINE, GAMS, et. al.	y	y	y	y	y	y	–	–	–	–	–	–	y	y	–	y	–	y	–	y	y	–	–
	Contact	y	y	Contact	y	y	–	–	–	y	–	–	–	y	IBM ILOG OPL-CPLEX Develop. Sys., AIMMS, et. al.	y	y	y	y	y	y	–	y	y	–	–	Indicator constraints	y	y	y	y	–	y	Populate solution pool	y	y	Sifting and network algorithms	Dyanmic Search; MIP Solution Pools; Deterministic Parallel MIP; Tuning Tool; Multiple MIP Starts; Solution Polishing API.
	Contact	y	y	$995 - $2,495 depending on options	y	y	Free restricted version available	–	–	y	y	y	y	y	IBM ILOG CPLEX, IBM ILOG CP Optimizer	y	y	y	–	y	y	Intervals	y	y	–	–	Logical constraints	y	y	y	y	–	y	–	y	y	–	Multi-model algorithms, warm-start, external calls to Java, decision expressions, performance profiler, automatic tuning.
	Contact	y	–	Contact	y	–	Free see website	–	–	–	–	–	–	–	AIMMS, AMPL, Excel, Frontline, GAMS, et. al.	y	y	y	–	–	–	–	y	y	y	y	See Website	–	y	y	–	–	y	Hybrid Quesada-Grossman method	–	–	Multi-start heuristics for global optmzn.	New funct. added to solve both linear and nonlinear models having binary or integer var.; improved multi-start gen. of start points.
	Contact	–	y	Contact	–	y	Contact	–	y	y	y	y	y	y	–	–	–	y	y	y	y	–	y	–	–	–	–	y	y	–	–	–	–	–	y	–	–	–
	Varies capacity/ options from $395	–	y	Varies capacity/ options from $195	–	y	Free download	–	y	–	–	–	–	y	Matlab, GAMS, LINGO and What'sBest	y	y	y	y	y	y	–	y	y	y	y	Non-smooth, non-convex functions	y	y	y	y	y	y	Global Solver, Multistart Solver, et. al.	y	y	Un-bounded & infeasi-bility analysis	Stochastic programming capabilities, statistical sampling, K-best MIP solver.
	Varies capacity/ options from $495	y	y	Varies capacity/ options from $245	y	y	Free download	–	y	y	y	y	y	y	LINDO API	y	–	y	y	y	y	–	y	–	y	y	Non-smooth, non-convex functions	y	y	y	y	y	y	Global Solver, Multistart Solver, et. al.	y	y	Un-bounded & infeasi-bility analysis	Stochastic programming capabilities, statistical sampling, K-best MIP solver.
	$2,000	y	y	$300	y	y	Free	–	–	–	–	–	–	y	AMPL	–	y	–	–	–	–	–	y	y	y	y	–	–	–	y	–	–	–	–	–	y	–	–	–
	Free MPL Contact	y	y	Free MPL Academ.; Contact standard prices	y	y	Free	y	y	y	y	y	y	y	CPLEX, GUROBI, XPRESS, OSL, XA, et. al.	y	y	y	y	y	y	Non-linear	y	–	y	y	Global	y	y	y	y	y	y	Stochastic Programming	y	y	–	Now giving FREE development copies of MPL. Free MPL with solver purchases, free MPL for Academics, and Subscription-Based Runtime pricing.
	$2,400 - $5,000	y	–	$480 - $1,000	y	–	–	–	–	y	y	y	y	y	–	–	–	y	y	y	y	–	–	–	–	–	–	y	y	–	–	–	–	–	y	–	MATEDIT, SOLVIEW, TABEDIT	–
	Contact	y	y	Contact	y	y	Contact	y	y	y	y	y	y	y	–	–	–	y	y	–	–	Partial integer	y	–	–	–	–	y	y	y	y	–	y	–	y	y	–	Major improvements in cutting planes and in parallel MIP; modeling language extensions; extended infeasibility diagnosis.
	Free OptiMax Development, Contact	y	y	Free OptiMax Academ.; Contact for prices	y	y	Free	y	y	y	y	y	y	y	CPLEX, GUROBI, XPRESS, OSL, XA, et. al.	y	y	y	y	y	y	Non-linear	y	–	y	y	Global	y	y	y	y	y	y	Stochastic Programming	y	y	–	Offers new language support, more than 20 new objects, w/ enhanced methods/properties for advanced solver handling and data management.

SOFTWARE PRODUCT LISTING

	Software Description								Platforms Supported												Size of Problem Solvable by This System									
	Type			Form					PC/ Windows		PC/ Linux		Other Unix-based		Other		Multiprocessor Support (list platforms)				Largest Version Limited By:				Demo/Student Version					
	Solver	Modeling Environment	Integrated Solver and Modeling Environment	Independent Application	Procedure/Callable Library	Object/Class Library	Source Code	Add-in To:	32-bit	64-bit	32-bit	64-bit	32-bit	64-bit	Specify	32-bit	64-bit	Specify	Shared Memory	Distributed Memory	Internal Restrictions	Max # of Constraints	Available Memory	Available Disk Space	Processor Architecture	Constraints	Variables	Integer Variables	Nonzeroes	Free or Open-Source	Free NEOS Server Access
Optware Enterprise *Optware Solutions LLC*	y	y	y	y	y	y	y	–	y	–	–	–	–	–	–	–	–	–	–	–	–	–	y	y	y	–	–	–	–	–	–
Premium Solver Platform *Frontline Systems Inc.*	y	y	y	–	–	–	–	Microsoft Excel	y	y	–	–	–	–	–	–	–	–	Windows	–	–	–	y	–	y	N/A	8,000	2,000	N/A	–	–
Quantitative Methods Software (QMS) *QuantMethods*	y	y	y	y	–	–	–	–	y	y	y	y	y	y	Mac OSX	–	–	–	–	–	–	–	y	–	–	–	–	–	–	–	–
Risk Solver Platform *Frontline Systems Inc.*	y	y	y	–	–	–	–	Microsoft Excel	y	y	–	–	–	–	–	–	–	–	Windows	–	–	–	y	–	y	N/A	8,000	2,000	N/A	–	–
SAS *SAS Institute Inc.*	y	y	y	y	–	–	–	–	y	y	y	y	y	y	–	–	–	z/OS, OpenVMS	–	–	–	–	y	y	y	No specific limit	No specific limit	No specific limit	No specific limit	–	–
Solver Platform SDK *Frontline Systems Inc.*	y	y	y	–	y	y	–	–	y	y	y	y	–	–	–	–	–	–	Windows, Linux	–	–	–	y	–	y	N/A	8,000	2,000	N/A	–	–
SOPT (Smart Optimizer) 4.2 *SAITECH, Inc.*	y	y	y	y	y	y	y	–	y		y		y	–	Solaris	–	–	–	–	–	–	–	–	–	–	500	500	500	Unlmtd.	–	–
SPInE *Optirisk Systems*	–	y	–	y	y	y	–	AMPL Studio	y	–	–	–	–	–	–	y	–	–	All supported platforms.	–	–	–	–	y	–	–	300	300	–	–	–	–
SYMPHONY *Distributed by the COIN-OR Foundation*	y	–	–	y	y	y	y	–	y	y	y	y	y	y	Cygwin, MSys, Solaris, Mac OSX, AIX	–	–	–	All platforms with a compiler	All above platform w/PVM instal.	–	–	y	y	y	–	–	–	–	y	–
TOMLAB *Tomlab Optimization Inc.*	–	–	y	–	–	–	–	MATLAB	y	y	y	y	y	–	Mac OSX	–	–	–	For CPLEX, GUROBI	With Star-P Environ-ment	–	–	y	y	–	–	–	–	–	–	–
Vanguard Business Analytics Suite *Vanguard Software*	y	y	y	y	–	–	–	–	y	y	–	–	–	–	–	–	–	–	–	–	–	–	y	y	–	–	–	–	–	–	–
Vanguard System for Web-based Optimization *Vanguard Software*	y	y	y	y	y	–	–	–	y	y	–	–	–	–	–	–	–	–	–	–	–	–	y	y	–	–	–	–	–	–	–
What'sBest *LINDO Systems, Inc.*	–	–	y	y	–	–	–	Excel	y	–	–	–	–	–	–	–	–	–	–	–	–	–	y	–	–	250	500	50	Unre-stricted	–	–
XA *Sunset Software Technology*	y	–	–	–	y	–	–	Extend, Excel, Python, Goldsim	y	y	y	y	y	y	–	–	–	–	PC Windows, PC Linux	–	–	–	y	–	–	–	–	–	–	–	–
YALMIP *YALMIP*	–	y	–	–	–	–	–	MATLAB	y	y	y	y	y	y	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	y	–

Pricing Information									Data Compatibility					Solvers or Modeling Environments			Formulations Supported											Algorithms											New Features
Commercial			Educational			Demo/Student											Variable Types (in addition to linear)				Constraint & Objective Types (in addition to linear)					Linear Programming			Integer Prog. (in addition to branch-and-bound)			Utility							
Single machine	Floating licenses available	Site licenses available	Single machine	Floating licenses available	Site licenses available	Single machine	Floating licenses available	Site licenses available	Reads Spreadsheets	Writes Spreadsheets	Reads Databases	Writes Databases	Reads and Writes Text	Solvers/Model Environments that Link to this Product	Bundled as a Single Pckg.	Available Separately	Integer, Binary	Semi-continuous	Arbitrary Discrete (SOS1)	Piecewise Linear (SOS2)	Other	Convex Quadratic Objective	2nd-Order Cone Constraints	General Convex	General Nonlinear	Other	Primal Simplex-based	Dual Simplex-based	Interior Point	Branch-and-cut	Branch-and-price Heuristics for Seeking Feasible Solutions	Other	Presolve	Infeasibility Diagnosis	Other	
$3,900+	y	y	–	–	–	–	–	–	y	y	y	y	y	XA, others	y	y	y	y	y	y	–	–	–	–	–	–	y	y	y	y	y	y	–	y	y	–	Microsoft Access 2007 version available
$1,895 with Annual Support	y	–	Contact	y	–	$0 Premium Solver for Edu.	y		y	y	y	y	y	5 built-in Solvers, 8 plug-in Solvers (See Online)	y	y	y	y	–	–	All different variable groups	y	y	y	y	Non-smooth arbitrary objectives constraints	y	y	y	y	y	y	Parallel Branch & Bound	y	y	–	New modeless user interface, parameterized optimizations, charts/graphs, multi-core nonlinear and global solvers, video demos
$19.95	–	y	$19.95	–	y	$19.95	–	y	–	–	–	–	–	–	–	–	y	y	–	–	–	–	–	–	–	y	y	–	y	–	–	–	–	y	Sensitivity Analysis	–
$3,995 with Annual Support	y	–	Contact	y	–	Contact - Risk Solver Platform for Edu.	y	–	y	y	y	y	y	5 built-in Solvers, 8 plug-in Solvers (See Online)	y	y	y	y	–	–	Recourse decision variables, all diff. var. groups	y	y	y	y	Chance constraints, et. al.	y	y	y	y	y	y	Parallel Branch & Bound	y	y	–	New: Modeless UI, parameterized optimizations & simulations, charts/graphs, multi-core simulation, nonlinear, global solvers, decision trees
Call	y	y	Call	y	y	SAS On-Demand for Academ.; Contact	y	y	y	y	y	y	y	–	–	–	y	–	–	–	–	y	–	y	y	–	y	y	y	y	–	y	–	y	y	–	Irreducible infeasible set analysis; enhancements to OPTMODEL modeling language; interior point nonlinear programming solver.
$1,995 with Annual Support	y	–	Contact	y	–	Contact	–	–	y	y	y	y	y	4 built-in Solvers, 8 plug-in Solvers (See Online)	y	y	y	y	–	–	All different variable groups	y	y	y	y	Non-smooth arbitrary objectives constraints	y	y	y	y	y	y	Parallel Branch & Bound	y	y	–	Visual Studio 2008 support, large library of examples
Contact	–	–	–	–	–	–	–	–	y	y	–	–	y	AMPL	y	y	y	–	y	–	–	y	y	y	y	–	y	–	y	–	–	y	Extended search and cutting planes	y	–	–	Extended search capabilities are further developed to find feasible solutions to large-scale integer programs. Cuts are automatically generated.
Contact	y	y	Contact	y	y	Free	–	–	y	y	y	y	y	FortSP, AMPL Studio	y	y	–	–	–	–	SP Problems with recourse	–	–	–	–	See Online Version	–	–	–	–	–	–	–	–	–	–	Added (Integrated) Chance Constraints support; .NET class library/Native procedural entry points. In memory communication w/ FortSP.
Free	–	–	–	–	–	–	–	–	–	–	–	–	y	GMPL, AMPL, GAMS	–	y	y	–	–	–	–	–	–	–	–	–	–	–	–	y	–	y	–	y	–	–	–
$1,170	–	y	$370	–	y	Free	–	–	y	y	y	y	y	tomSym (mod. environment), CPLEX, and more	–	y	y	y	y	y	–	y	y	–	–	–	y	y	y	y	y	y	–	y	y	–	PROPT - optimal control platform. tomSym - modeling environment for MATLAB.
$3,395	y	y	$1,698	y	y	Free 15-day trial	–	–	y	y	y	y	y	–	–	–	y	y	y	y	No restrictions in Stoch. Opt. mode	y	y	–	–	No restrictions in Stoch. Opt. mode	y	–	–	–	–	y	–	–	–	Grid Comp. available in Stoch. Opt. mode	Stochastic Optimization. Grid computing. Web services. Collaborative modeling.
Starting at $5,950 per year	y	y	Starting at $2,975 per year	y	y	Free 15-day trial	–	–	y	y	y	y	y	–	–	–	y	y	y	y	No restrictions in Stoch. Opt. mode	y	y	y	y	No restrictions in Stoch. Opt. mode	y	–	–	–	–	y	–	–	–	Grid Comp. available in Stoch. Opt. mode	Development tool for Web-based Optimization. Stochastic Optimization. Grid computing. Web services. Collaborative modeling.
Varies capacity/ options from $495	y	y	Varies w/cap.; options from $245	y	y	Free download	–	y	y	y	y	y	y	LINDO API	y	–	y	y	y	y	–	y	–	y	y	Non-smooth, non-convex functions	y	y	y	y	y	y	Global Solver, Multistart Solver, et. al.	y	y	Unbounded & infeasibility analysis	Stochastic programming capabilities, statistical sampling, K-best MIP solver, expanded function support.
Contact	y	y	–	–	–	–	–	–	y	–	y	–	y	AIMMS, GAMS, MPL, and AMPL	y	y	y	y	y	y	–	y	–	–	–	–	y	y	y	y	–	y	–	y	y	–	Conflict Analysis, Piece-wise linear, concurrent Primal and Dual Algorithm, Extend and Goldsim interfaces.
–	–	–	–	–	–	–	–	–	–	–	–	–	–	BINTPROG, BPMPD, CDD, CLP, CPLEX, CSDP, et. al.	–	–	y	y	–	–	Parametric, Uncertain	y	y	y	y	Semi-definite constraints	–	–	–	–	–	–	–	–	–	–	–

continued from p.47

branch-and-bound solver continues to grow even after decades of attention, with increasingly sophisticated features such as **branch-and-cut, branch-and-price** and **feasibility-seeking heuristics** becoming available to a broader range of users. These refinements make more integer programs tractable but also place more responsibility on the user to study and select wisely among available options. Although MIP solvers attempt to choose options according to characteristics of the problem at hand, these default choices cannot be relied upon to work well for all hard MIPs. Users may find it necessary to "tune" algorithmic options through experimentation; some solvers provide suggestions for making good choices, but explicitly automated tuning is still at an early stage.

Problem Types

MANY PACKAGES seek to address their users' needs by supporting varied specializations and generalizations of LPs and MIPs.

In the area of discrete optimization, the ideas underlying branch-and-bound search for integer programming are sufficiently powerful to handle broader classes of constraint types. Indeed, MIP solvers have long accommodated variables that take values from an arbitrary list (via special ordered sets of type 1 or **SOS1** search rules) and objectives or constraints that incorporate non-convex piecewise-linear terms (via **SOS2** rules). Many solvers also have special search rules to help with **semi-continuous** or **semi-integer** variables, which must take a pre-specified value (usually zero) or lie in a designated positive range. Additional kinds of logical constraints, such as if-then and all-different, are becoming more common as specialized search techniques are adapted from related developments in so-called constraint programming software. The distinction between integer and constraint programming is thus continuing to fade, though it will not likely disappear for some time yet.

Convex quadratic objectives and constraints, in continuous or integer variables, are another popular extension as seen in the table. Linear programming further extends to **cone programming** and to **semidefinite programming,** in which non-negativity of individual variables is generalized to membership in a specified pointed cone. Problems of these types find varied applications in engineering and design, and provide strong approximations to some hard combinatorial problems; a search of the Web readily yields several collections of test problems. Interior-point methods extend to solve these problems, though not so easily as in the case of LPs. Problems of these kinds are becoming more familiar as modeling languages and problem formats catch up with them.

A number of products listed in the table can handle some more **general nonlinear** problems as well. There are quite a few

VENDOR DIRECTORY

Advanced Mathematical Software Ltd
46 Frensham Vale
Farnham, Surrey GU10 3HT UK
Phone: 01252 792602
info@amsoft.demon.co.uk
www.amsoft.demon.co.uk

AMPL Optimization LLC
900 Sierra Place SE
Albuquerque, NM 87108-3379 USA
Phone: 847-846-8486
Fax: 425-940-6286
info@ampl.com
www.ampl.com

COIN-OR
cbc@list.coin-or.org, coin-lpsolver@list.coin-or.org, tim.hultberg@eumetsat.int, ted@lehigh.edu
www.coin-or.org/projects/Cbc.xml,
www.coin-or.org/projects/Clp.xml,
https://projects.coin-or.org/FlopC++,
https://projects.coin-or.org/SYMPHONY

Free Software Foundation, Inc.
51 Franklin Street, Fifth Floor
Boston, MA 02110-1301 USA
Phone: 617-542-5942
Fax: 617-542-2652
info@fsf.org
www.gnu.org/software/glpk/

Frontline Systems Inc.
P.O. Box 4288
Incline Village, NV 89450 USA
Phone: 775-831-0300
Fax: 775-831-0314
info@solver.com
www.solver.com

GAMS Development Corporation
1217 Potomac Street, NW
Washington, DC 20007 USA
Phone: 202-342-0180
Fax: 202-342-0181
sales@gams.com
www.gams.com

Gurobi Optimization, Inc.
P.O. Box 1001
3733-1 Westheimer Road
Houston, Texas 77027 USA
Phone: 713-871-9341
Fax: 713-960-0793
info@gurobi.com
www.gurobi.com

IBM
1681 Route des Dolines
Les Taissounieres HB2
Valbonne 06560 France
Phone: +33 4 9296 8672
Fax: +33 4 9296 6162
info@ilog.fr
www.ilog.com/products/oplstudio/

ILOG, an IBM Company
1195 West Fremont Avenue
Sunnyvale, CA 94087-3832 USA
Phone: 408-991-7000
Fax: 408-991-7001
info@ilog.com
www.ilog.com

Ketron Optimization
45573 Shepard Drive, #201
Sterling, VA 20164-4409 USA
Phone: 703 433 1310
Fax: 703 433 1312
info@ketronms.com
www.ketronms.com

LINDO Systems, Inc.
1415 North Dayton Street
Chicago, IL 60642 USA
Phone: 312-98807422
Fax: 312-988-9065
info@lindo.com
lindo.com

Maximal Software, Inc.
2111 Wilson Boulevard, Suite 700
Arlington, Virginia 22201 USA
Phone: 703-522-7900
Fax: 703-522-7902
info@maximalsoftware.com
www.maximalsoftware.com

OM Partners
Koralenhoeve 23
2160 Wommelgem (Antwerp) Belgium
Phone: + 32-3-650-22-11
Fax: + 32-3-650-22-90
sales@ompartners.com
www.ompartners.com

Optimalon Software
500 Hidden Creek Dr
Kitchener, Ontario N2N3M1 Canada
info@optimalon.com
www.optimalon.com

Optirisk Systems
Optirisk R&D House
1, Oxford Road
Uxbridge, Middlesex UB9 4DA UK
Phone: +44 (0) 1895 819 483
Fax: +44 (0) 1895 813 095
info@optirisk-systems.com
www.optirisk-systems.com

Optware Solutions LLC
12725 SW Millikan Way, Suite 300
Beaverton, OR 97005 USA
Phone: 503-645-2390
info@optware.com
www.optwaresolutions.com

Paragon Decision Technology Inc.
5400 Carillon Point
Kirkland, WA 98033 USA
Phone: 425-576 4060
Fax: 425-576 4061
info@aimms.com
www.aimms.com

Princeton University
106 Sherrerd Hall, Princeton University
Princeton, NJ 08544 USA
Phone: 609-258-2345
rvdb@Princeton.EDU
www.princeton.edu/~rvdb

QuantMethods
9644 Oak Meadow, Suite 100
Pilot Point, TX 76258 USA
Phone: 940-231-1949
sales@quantmethods.com

good solvers intended exclusively for nonlinear optimization that do not appear, but that can be found in other listings and surveys.

Trends

A SCAN OF THE **NEW FEATURES** doesn't reveal much of a pattern this time around. The next big advance in LP solving or modeling might be out there, but if so it hasn't made quite enough of an impact yet to be clearly identifiable as the next big thing. **IORMS**

Robert Fourer *(www.iems.northwestern.edu/~4er/), professor of Industrial Engineering and Management Sciences at Northwestern University, is one of the designers of the AMPL modeling language for mathematical programming and the NEOS Server facility for optimization over the Internet. His recent interests include detection and transformation algorithms for making optimization problems amenable to a greater range of solvers, and modeling language support for nontraditional optimization.*

NOTE:

The information included in this survey was provided by vendors and not independently verified. Due to space limitations, not all of the vendors who responded appear in the survey. In other instances, answers to some questions were edited to fit. For a more complete survey, including vendors who responded after the deadline, go to: **http://www.lionhrtpub.com/orms/surveys/LP/LP-survey.html.**

SAITECH, Inc.
P. O. Box 431
Holmdel, New Jersey 07733 USA
Phone: 732-332-9700
Fax: 732-332-7823
logi@saitech-inc.com
www.saitech-inc.com

SAS Institute Inc.
SAS Campus Drive
Cary, NC 27513 USA
Phone: 919-677-8000
Fax: 919-677-4444
www.sas.com

Sunset Software Technology
1613 Chelsea Road, Suite 153
San Marino, CA 91108 USA
Phone: 626-441-1565
Fax: 626-441-1567
jim@sunsetsoft.comn
www.sunsetsoft.com

Tomlab Optimization Inc.
1260 SE Bishop Blvd Ste E
Pullman, WA 99163 USA
Phone: 509-320-4213
Fax: 619-245-2476
us@tomopt.com
tomopt.com/tomlab/

Vanguard Software
1100 Crescent Green
Cary, NC 27518 USA
Phone: 919-859-4101
Fax: 919-851-9457
sales@vanguardsw.com
www.vanguardsw.com

YALMIP
Division of Automatic Control
Linköping University
Linköping 581 83 Sweden
Phone: +46 13-282622
johanl@isy.liu.se
www.yalmip.org

Ziena Optimization, Inc.
1801 N. Maple Avenue
Suite 6320, Mailbox #55
Evanston, IL 60201 USA
Phone: 847-491-2504
Fax: 847-556-0668
info@ziena.com
www.ziena.com

advertiser INDEX

INFORMS NEWS

INSIDE

PREVIEW OF SAN DIEGO CONFERENCE

The INFORMS Annual Meeting will be held Oct. 11-14 at the brand new Hilton San Diego Hotel and San Diego Convention Center.

The conference will offer plenty of opportunities for networking with colleagues at the INFORMS Membership Meeting and Reception on Saturday, the Welcome Reception on Sunday, a multitude of intimate receptions to choose from on Monday evening and the General Reception on Tuesday evening at the famous SeaWorld Adventure Park (with a private evening Shamu Show for INFORMS attendees).

The four days will be packed with plenaries, tutorials and research seminars.

Plenary and keynote speakers include: QUALCOMM founder Irwin Jacobs, Richard Larson, Thomas Magnanti and Yossi Sheffi of MIT, Christopher Tang of UCLA and Omega Rho Distinguish Lecturer Karel Lenstra of the Eindhoven University of Technology. More than 20 tutorials are also planned.

For the most up-to-date information, go to http://meetings.informs.org/sandiego09/.

– Soheila Jorjani

2009 INFORMS COMBINED COLLOQUIA

The 2009 INFORMS Combined Colloquia will be held on Oct. 9-10, the Friday and Saturday preceding the INFORMS Annual Meeting in San Diego. This Combined Colloquia will feature the:

- Teaching Effectiveness Colloquium
- Future Academician Colloquium
- Future Practitioner Colloquium

All three colloquia are sponsored by INFORMS, INFORM-ED, the INFORMS Student Affairs Committee and Omega Rho, and are designed to provide the attendees with technical material, career experiences from senior and junior OR/MS professionals, and an environment for networking.

The Teaching Effectiveness Colloquium will address several aspects of incorporating and assessing effective teaching techniques in any undergraduate and graduate curriculum. The colloquium will be beneficial to both seasoned and new faculty members at all levels and in all disciplines of operations research and management science. Planned sessions include topics such as understanding what the best college teachers do, exposure to a variety of teaching strategies for engaging students in the classroom and extending learning outside the classroom, and an overview of possible pedagogical scholarship in OR/MS.

The Future Academician Colloquium is organized with current doctoral students in mind. It will include sessions dedicated to navigating the job hunt, developing a successful research program, becoming an effective teacher and dealing with work-life balance issues.

The Future Practitioners Colloquium has been organized with current doctoral student participation in mind; however, applications will be accepted for new practitioners (those within three years of starting their first practice job) as well. This colloquium will feature sessions focusing on career paths for OR/MS professionals, challenges that new practitioners experience, discussions concerning choosing between an academic and a practice career, what managers seek when hiring new employees, and suggestions concerning how to find a job as well as how to become a successful OR/MS practitioner.

Combined Colloquia, *continued on p.58*

2009 INFORMS Combined Colloquia

continued from p.57

The Teaching Effectiveness Colloquium will begin at 7:30 a.m. Oct. 9. The Future Academician and Future Practitioner Colloquia will begin at 6 p.m. that same evening with a welcome dinner for all participants. Don Kleinmuntz, president of INFORMS, will address the participants on the future of INFORMS and its position at the center of teaching, research and practice. The Combined Colloquia will continue on Saturday all day with several sessions. Following the conclusion of the colloquia, all participants will be invited to an evening dinner. Participants will also have opportunities to interact with each other and with the Combined Colloquia speakers during breakfast, lunch and several refreshment breaks.

Participant Nomination

Because of increased demand and limited capacity, consideration for participation in the colloquia is by nomination only. A department can nominate more than one eligible individual to each colloquium, but only a limited number of applicants will be accepted. However, nominations of one person to multiple colloquia are not permitted and will not receive consideration. Companies can nominate eligible practitioners to just the Future Practitioner Colloquium.

The registration fee for each of the Colloquia is $300. However, the fee will be waived for one participant from a department nominated to the Combined Colloquia. A second participant from a department to the colloquia pays $150, and each additional participant pays $300. All Future Practitioners Colloquium attendees nominated by a company must pay $300. Invoices for the total amount will be sent directly to the sponsor units (department or company). No invoice will be sent to individual participants.

All colloquia participants are required to register for the INFORMS Annual Meeting in San Diego. The registration fee for the colloquia does not include the registration fee for the INFORMS Annual Meeting.

Deadline for all nomination packages is July 15. For complete nomination requirements, go to: http://meetings.informs.org/sandiego09/

Jill Hardin (jrhardin@vcu.edu) chairs the Combined Colloquia Committee, joined by Brady Hunsaker, Larry Snyder, Matt Drake and Cliff Ragsdale. IORMS

Review of *Decision Analysis* Journal

In accordance with INFORMS policy and procedures, the INFORMS VP for Publications, Terry Harrison, has appointed a committee to review the *Decision Analysis* journal and consider the reappointment of Robin Keller as editor-in-chief for a second three-year term. Keller has provided a report on the journal and the committee will conduct a survey as part of the review process.

The committee includes Greg Parnell (United States Military Academy and committee chair), Manel Baucells, (IESE Business School, Barcelona), Robin Dillon-Merrill (Georgetown University), Jim Felli (Eli Lily Company), Warren Powell (Princeton University and INFORMS Publications Committee representative) and Candita Gerzevitz (liaison from the INFORMS office).

The final report is due on Aug. 1. The committee will be sending a survey to *Decision Analysis* subscribers and interested INFORMS members. Please respond to the survey and feel free to provide any feedback on the journal to the committee chair (gregory.parnell@usma.edu) or any committee member. IORMS

ASU Hosts Regional Conference

U.S. Air Force Academy team celebrates capstone project victory.

At the INFORMS Western Regional Conference held in April at Arizona State University, student teams presented papers in the "Best Undergraduate Capstone Project" competition. The U.S. Air Force Academy team won with their paper, "Fighter Basing Analysis for Continental U.S. Protection." Team members included cadets David Ocampo, Philip Cunningham and Michael Peterson. Lt. Col. Maureen Borgia served as faculty advisor.

National University, including team members Daniel Hathaway, Art Saldana, Daryl Smith, Kyle Downing and faculty advisor Albert Cruz, finished second.

Volunteers from INFORMS Student Chapter members at ASU and the University of Arizona helped make the conference a success. IORMS

Call for Nominations

Simulation Society's Lifetime Professional Achievement Award

The Lifetime Professional Achievement Award (LPAA) of the INFORMS Simulation Society is the highest honor given by the Society. The purpose of this award is to recognize major contributions to the field of simulation that are sustained over a professional career, with the critical consideration being the total impact of those contributions on computer simulation. Past recipients include: Richard Nance, Jack Kleijnen, George Fishman, Robert Sargent, Thomas Schriber, Alan Pritsker and Julian Reitman. An individual's contributions may fall in one or more of the following areas: research, development of software or hardware, practice, service to the simulation profession, dissemination of knowledge and advancement of the status or visibility of the field.

A nominee is not expected to demonstrate contributions in each area. A full description of the Award Rules can be found at www.informs-sim.org/lpaafcm.html .

The annual award consists of a plaque and reasonable travel expenses incurred by the recipient when attending the presentation ceremony. If given, the award will be presented in December during the opening session of the Winter Simulation Conference.

Individuals selected for this award should normally be in or near their retirement, and the award may be given posthumously. Nominations may be submitted in the form of pdf files by anyone (including self-nominations), but they may not be made anonymously. The burden of offering evidence of merit falls on the nominator. Each nomination should include:

1) the nominee's complete resume;
2) a clear-cut, comprehensive description of the nominee's major contributions to the profession, with complete supporting documentation; and
3) at least three letters of endorsement providing evidence of the significance and magnitude of the nominee's professional achievements.

Nominations for this award must be received by the chair of the LPAA Selection Committee no later than Sept. 1. Send completed nominations, including all supporting letters and documentation, if possible in the form of pdf files attached to a single e-mail to the committee chair: Richard E. Nance (nance@vt.edu). Keebom Kang and Enver Yucesan are also members of the committee. INFORMS

Call for Nominations

Award for the Advancement of Women in OR/MS

The Award for the Advancement of Women in OR/MS celebrates and recognizes a person who has contributed significantly to the advancement and recognition of women in the field of operations research and the management sciences (OR/MS). Each nominee will be considered based on his or her history of successfully promoting the professional development, success and recognition of women in OR/MS. Nominees can have made contributions in multiple ways, such as primarily at their own institutions, through involvement in professional organizations, etc.

Examples of activities to be considered include, but are not limited to, the following: personal commitment and/or leadership with respect to increased hiring, retention, advancement and recognition of women (students and faculty) in academia, industry or government; leadership in encouraging, sponsoring, and/or developing professional training/development programs for women in OR/MS; creating an environment that supports women's full participation and advancement in the field of OR/MS, possibly through mentoring, leadership, financial support and/or personal investment of time.

Nominations should include:

- nominee's name, affiliation, address, telephone, fax, e-mail;
- a short (250-500 words) description of the nominee's overall contribution to the advancement of the careers of women in OR/MS;
- description(s) of specific activities, programs, leadership;
- statements of support from women in OR/MS and/or from organizations that observed or benefited from the nominee's activities; and
- the nominee's résumé and other items as appropriate.

All nominations must be submitted via e-mail to the Award Committee Chair Anna Nagurney by July 1. One award (in the form of a plaque) will be given, if there is a suitable candidate. The award will be presented to the winner during the 2009 INFORMS National Meeting in San Diego.

For questions, please contact the 2009 Award Committee Chair: Anna Nagurney, John F. Smith Memorial Professor, Department of Finance and Operations Management, Isenberg School of Management University of Massachusetts, Amherst, MA 01003; phone: 413-545-5635; fax: 413-545-3858; e-mail: nagurney@gbfin.umass.edu .INFORMS

PEOPLE

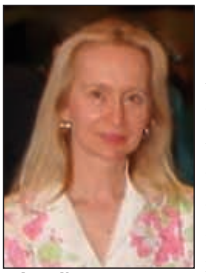
Send People items to Peter Horner via e-mail at: horner@lionhrtpub.com


J. George Shanthikumar

J. George Shanthikumar, the Chancellor's Professor in the Department of Industrial Engineering and Operations Research at the University of California at Berkeley, has been named the first Kenan Distinguished Visiting Scholar by the Kenan-Flagler Business School at the University of North Carolina at Chapel Hill. The visiting scholars program was created by Jayashankar Swaminathan, Kenan-Flagler's senior associate dean of academic affairs, to bring leaders from various business fields to Kenan-Flagler in order to collaborate and exchange ideas with students and faculty.

Shanthikumar was selected for the honor by faculty in both the Operations Technology and Innovation Management Area of the Kenan-Flagler Business School and the Operations Research group in the Department of Statistics and Operations Research. He was recognized for his outstanding record of research and scholarly activity in the design, analysis and control of stochastic systems and his contributions in applying his research to improve manufacturing systems. During his weeklong residence at UNC, Shanthikumar presented three lectures – one on stochastic orders, one on modeling uncertainty in stochastic systems and one on research applications in the semiconductor industry.

Shanthikumar has published more than 200 scholarly articles and is the author of three books: "Stochastic Models of Manufacturing Systems" (with J. A. Buzacott), "Stochastic Orders and Their Applications" (with M. Shaked) and "Stochastic Orders" (with M. Shaked).


Anna Nagurney

Anna Nagurney, John F. Smith Memorial Professor in the Department of Finance and Operations Management, Isenberg School of Management, University of Massachusetts, Amherst, will be a speaker at the 2009 World Science Festival in New York City June 10-14. The festival's mission is to "cultivate and sustain a general public informed by the content of science, inspired by its wonder, convinced of its value, and prepared to engage with its implications for the future." Professor Nagurney, the director of the Virtual Center for Supernetworks and the Supernetworks Laboratory for Computation and Visualization at UMass Amherst, will join an impressive list of scientists, inventors,

IN MEMORIAM

ERNEST KOENIGSBERG (1923-2009)

Ernest Koenigsberg, a professor emeritus at the University of California, Berkeley's Haas School of Business and an expert in operations research and management science, with a focus on transportation, died on April 20 of heart failure at his home in San Francisco. He was 86.

Professor Koenigsberg, born on April 15, 1923, in Brooklyn, N.Y., earned an undergraduate degree in physics at New York University in 1948 and a Ph.D. in theoretical physics at Iowa State in 1953. He went on to work at the Midwest Research Institute in Kansas City, Mo., where he changed his field to operations research. He worked with many different industries, including plywood production, shipping and warehousing, before he started teaching at the Haas School.

Professor Koenigsberg joined the Haas School as a lecturer in 1963 and was promoted to senior lecturer in 1975. He was appointed professor in 1982 and served on two of the Haas School's faculty groups: Economic Analysis & Policy and Operations Research & Information Technology. He retired in 1991.

"He embodied everything we wanted in the classroom," said former Haas School dean and faculty colleague Raymond Miles. "He was an excellent teacher who could bring real-world experience into his classes."

Professor Koenigsberg was part of an early group of Haas School faculty that took an interest in management science, a discipline that blossomed after World War II when its application to military production issues started spilling over into industrial uses. Management science applies analytical processes and quantitative techniques to production, inventory, distribution, scheduling and control problems.

Professor Koenigsberg's work focused primarily on transportation issues such as fleet operations, transoceanic tug barge systems and ship allocation. He served as a long-time consultant to Matson, the ocean transportation company. He also served on a panel on future U.S. port requirements with the Maritime Transportation Research Board of the National Research Council.

Professor Koenigsberg was a founding and active member of the Operations Research Society of America. He also served as a member of the Institute of Management Sciences and the Econometric Society, as an associate editor of the Operational Research Society in the United Kingdom and of the Canadian Operations Research Society and as a fellow of the Royal Statistical Society in Great Britain.

In later years, he became interested in the history of the operations research discipline and focused on the use of mathematical models in production during the 19th century.

He taught for brief periods in UC Berkeley's and Stanford University's industrial engineering departments and at the University of Pennsylvania's Wharton School.

Koenigsberg was known for his warm personality, extensive knowledge and ready ability to discuss numerous disparate topics, said his family.

"My father loved Berkeley - the academic community, the campus, the community at large," said his son, Martin Koenigsberg. "He was here during the 1960s and experienced the gas attacks from the helicopters. He saw that whole story unfold."

Miles recalled Koenigsberg's special talent for photography, saying it "endeared him to a lot of people. You could always see him at faculty functions taking pictures, which he later shared."

He is survived by his wife of 54 years, Susan; daughter, Joanna of London; son, Martin of Los Angeles; and four grandchildren. A memorial service was held on April 26 at Temple Emanu-El in San Francisco. IORMS

Donations may be sent to the American Friends of The Hebrew University, One Battery Park Plaza, 25th Floor, New York, N.Y. 10004

– Ute Frey

philosophers, artists, authors, actors and others on the list of speakers (see www.worldsciencefestival.com/speakers).

Jayashankar M. Swaminathan

Jayashankar M. Swaminathan, the Kay and Van Weatherspoon Distinguished Professor of the Operations, Technology and Innovation Management Area at the Kenan-Flagler Business School, University of North Carolina at Chapel Hill, and the VP of Education of INFORMS, has edited a new book, "Indian Economic Superpower: Fiction or Future?" (World Scientific Publishing, 2009). India has become an integral part of global supply chains today. The book provides an in-depth look at challenges and opportunities related to various sectors including manufacturing, offshoring, software, logistics, aviation, healthcare and marketing. It has a number of case examples from these sectors that will be valuable to anyone interested in supply chains spanning India or other emerging economies.

With contributions from leading academics and managers, this book provides depth and breadth in terms of topics covered and is geared towards students, researchers and practicing managers.

INFORMS members ***Stephen M. Robinson*** of the University of Wisconsin-Madison, ***Eva Tardos*** and ***Michael J. Todd*** of Cornell University and ***Margaret H. Wright*** of New York University were among 183 individuals named to the Society for Industrial and Applied Mathematics' inaugural Fellows Class. Fellowship is an honorific designation conferred on members distinguished for their outstanding contributions to the fields of applied mathematics and computational science.

"The announcement of the first class of SIAM Fellows is an important milestone for the applied mathematics and computational science community," said SIAM President Douglas N. Arnold. "Reflecting the diversity of the SIAM membership, these men and women come from five continents, and work in academia, industry and government laboratories. Advancing the frontiers of research in branches of mathematics as distinct as number theory and partial differential equations, these professionals have applied their work to endeavors ranging from mining to medicine. They have designed algorithms to make computing possible and written textbooks to train the next generation of mathematicians. Their contributions are truly outstanding."

The distinction of SIAM Fellow in 2009 is bestowed upon members who meet at least one of the following criteria: members of select national academies in countries where SIAM members constitute at least 1% of total SIAM membership; recipients of select SIAM and International Council for Industrial and Applied Mathematics (ICIAM) prizes; present and past fellows of select corporate and laboratory programs at SIAM institutional member organizations (programs whose selection procedures are well-correlated with the goals of the SIAM Fellows Program); editors-in-chief of SIAM journals since 1998; and former and current presidents of SIAM.

Following 2009, the anticipated number of fellowships conferred annually will be approximately 0.3 percent of the number of regular SIAM members. ORMS

INFORMS Meetings

INFORMS National & International Meetings 2009

June 14-17
CORS/INFORMS International Toronto 2009
Westin Harbour Castle
Toronto, Ontario, Canada

Chair: Liping Fang, Ryerson University
http://meetings.informs.org/Toronto09/

Oct. 11-14
INFORMS Annual Meeting 2009 San Diego
San Diego Convention Center and Hilton San Diego
San Diego, Calif.

Chair: Soheila Jorjani, California State University-San Marcos
http://meetings.informs.org/SanDiego09

2010

June 6-9
ALIO-INFORMS International
Law School, Univ. of Buenos Aires
Buenos Aires, Argentina

Chair: Irene Loiseau, University of Buenos Aires
irene@dc.uba.ar

Nov. 7-10
INFORMS Annual Meeting 2010 Austin
Austin Convention Center and Hilton Austin
Austin, Texas

Chair: Jonathan Bard, University of Texas at Austin
jbard@mail.utexas.edu

2011

Nov. 13-16
INFORMS Annual Meeting 2011 Charlotte
Charlotte Convention Center
Charlotte, N.C.

Chair: Cem Saydam, University of North Carolina at Charlotte
saydam@uncc.edu

2012

Dates to be announced
INFORMS International Beijing
In conjunction with the Operations Research Society of China
Beijing, China

Oct. 14-17
INFORMS Annual Meeting 2012 Phoenix
Phoenix Convention Center
Phoenix, Arizona

Chair: Ronald Askin, Arizona State University
ron.askin@asu.edu

INFORMS Subdivision Meetings 2009

June 22-23
Revenue Management & Pricing Conference
Northwestern University, The Kellogg School
Evanston, Ill.

Chair: Martin Lariviere, The Kellogg School
http://www.kellogg.northwestern.edu/research/operations/revenue2009/registration.html

June 28-30
MSOM And SIGs Meetings
MIT
Cambridge, Mass.

Chairs: Stephen Graves, Gabriel Bitran, MIT
http://mitsloan.mit.edu/omg/msom2009/

July 12-15
Applied Probability Society Conference
Cornell University
Ithaca, N.Y.

Chairs: Shane Henderson, Mark Lewis, Cornell University
http://appliedprob.society.informs.org/apsconf09/APS09.html

Aug. 6-7
INFORMS Service Science Conference
The Hong Kong University of Science & Technology
Hong Kong, China

Chairs: Robin G. Qiu, Fugee Tsung
http://informs09.ielm.ust.hk/

Dec. 13-16
Winter Simulation Conference 2009
Hilton Austin
Austin, Texas

Chair: Ann Dunkin, Hewlett-Packard
www.wintersim.org

August 23-28, 2009

20th International Symposium on Mathematical Programming
University of Chicago, Gleacher Center & Marriott Chicago Downtown
Chicago, Ill.
Chair: John Birge, University of Chicago
http://www.ismp2009.org/

Go to www.informs.org/Conf for a searchable INFORMS Conference Calendar.

IBM to Open Network of Analytics Centers

IBM recently announced a significant expansion of its capabilities around business analytics with plans to open a network of Analytics Solution Centers around the world, beginning with five this year. These initial centers will be located in Tokyo, London, New York City, Beijing and Washington, D.C. As part of this initiative, IBM will retrain or hire as many as 4,000 new analytics consultants and professionals.

The centers will enable IBM to meet growing client demand for advanced analytics capabilities as part of new, smarter business systems. Much of this demand is driven by new stimulus investments around the world in areas such as financial risk management, smart grids, electronic medical records and food tracking. These clients are embedding new sensor technology into their processes in order to gather better performance and management data. Organizations are then leveraging new analytics capabilities to turn that data into predictive intelligence to help run new digital infrastructures more effectively and smarter.

"Advanced analytics are increasingly essential to help companies and organizations confronted with vast amounts of data and systemic change, and who are looking to build smarter business systems," says Samuel J. Palmisano, IBM's chairman, president and chief executive officer. "All organizations today need to sort through myriad choices, make smarter decisions quickly and accurately, and act decisively."

The first three centers will sit in the world's financial hubs – Tokyo, London and New York City. Staffed initially with more than 100 consultants and mathematicians each, these centers will serve clients seeking a deeper, system-level view of financial risk across markets as they pursue more predictive business outcomes in the new economic condition.

The IBM Analytics Solution Centers initially will be staffed with domain experts from across IBM. As demand grows, IBM will shift training investments to hire or retrain 4,000 high-skilled workers needed for these next-generation positions.

IBM, which acquired ILOG last year, also announced new optimization software, IBM ILOG CPLEX 12. Deployed in a wide range of businesses, governments and quasi-governmental agencies, the software will help technicians find solutions to complex problems, identify trends and predict outcomes in everything from weather forecasting to transportation scheduling and financial performance.

SAS Adds New Capabilities to Aid Analysts

SAS Institute (www.sas.com) recently announced several new software products that should be of interest to OR/MS analysts and others involved in improving decision-making. Among the new products are:

• ***Sim Studio,*** a discrete-event simulation package with graphic user interface (GUI) and animation output, integrated fully with the main SAS package. This enables users to draw data and fit distributions of interarrival times, service times, flows, splits and other operating parameters directly from observed operational data, input those distributions directly into the simulation, embed the simulation runs within an experimental design, and produce a full response surface output depicting the results, and use the response distribution as input to an optimization, all in one package. A version in JMP is anticipated this summer, as well.

• ***Social Network Analyzer,*** embedded in the Fraud Detection package. This capability to draw social networks from contact data, possibly from multiple sources, integrated with main SAS, makes it possible to link patterns of behavior, such as medical claims submissions, with information about the associations of the party of interest. For example, a known fraudster can be readily linked to previous business partners and other people who went through claims coding classes with him, to see whether their claims show the same patterns.

• ***Hash*** objects fully embedded in Data steps. Hash objects are extremely computationally efficient linked arrays that make it possible to store and retrieve data using a computed index rather than a keys table that has to be sorted or accessed sequentially. For very large update, merge and selective extract operations, this approach reportedly can decrease run time by as much as 80 percent, even when compared to efficient sort / merge / update programs.

The announcements came at the SAS Global Forum at Washington Harbor near Washington, D.C. The conference theme was "Competing on Analytics." Former Secretary of State Madeleine Albright keynoted the executive track, speaking about "Leading with Confidence in an Era of Uncertainty."

– Doug Samuelson

LINDO API 6.0 Boasts New Features

LINDO Systems has begun shipping a new release of LINDO API that includes new features to allow users to incorporate uncertainty into their optimization models. LINDO API 6.0 also includes enhancements to the linear, integer and global solvers.

Release 6.0 includes a new interface that supports optimization for models with uncertain elements via multistage stochastic linear, nonlinear and integer stochastic programming (SP). The SP interface has a comprehensive set of API functions to setup and solve SP models of all types including Benders decomposition for large linear models. Deterministic equivalent method is used for solving nonlinear and integer SP models. More than 20 distribution types are supported (e.g., Normal, Poisson, etc.), and users can also define their own functions.

Also new is a Statistical Sampling API that includes functions to sample directly from various statistical distributions. Variance reduction is available with Latin-Hyper-Cube and Anti-thetic variates sampling. The new release allows the generation of correlated samples via Pearson, Spearman or Kendall correlation measures. A pseudo random uniform generation API allows a choice of three different generators.

LINDO API 6.0 includes several new enhancements to the solvers. The Primal and Dual Simplex solvers are an average of 20 percent faster. The Global Solver includes several improvements in the handling of nonlinear models with quadratic terms, especially non-convex quadratic expressions. Limited capacity trial versions of the LINDO API 6.0 can be downloaded at http//www.lindo.com. IORMS

BI (Business Intelligence) Analyst. NY, NY. MBA-Marketing or BI. 2 yrs experience in job or as Business Planning, Operation Research or Market Research Analyst. **Job duties:** Perform BI analysis & modeling on profitability, sales, operations, supply chain, market strategy, competitive analysis; Conduct qualitative analysis using Strategic Analysis Framework; Gather, sort, analyze, data; Develop software system using MS.NET framework or Java; Develop data warehouse using MS SQL Server; Apply marketing analysis technique, e.g. regression, segmentation, clustering, to address global beverage industry and deliver business intelligence. Design and validate computerized stimulation and time-series forecasting model. Generate reports using IIS server, .Net framework, ASP.NET & C#. **Technical knowledge must include:** Decision Tree, Monte Carlo Simulation, Linear programming; SWOT, Porter's Five forces, Value Chain Analysis, BCG chart & Game Theory; ARIMA, Winter's Seasonality, Linear Exponential Smoothing models; Crystal Ball, Solver, Tree Plan; Statgraphics or SPSS; MS SQL Server database, SQL, Access, MS Office Programming, Java, .Net framework, C#, Visual Basic, ASP.NET, PHP. Send resume to: **B. Carey, Beverage Marketing Corp. of NY, 850 Third Ave., NY, NY 10022**

CLASSIFIED ADVERTISING RATES AND CONTACT INFORMATION:

Bold Face Headline: $49 per line. **Body text:** $26 per line. **Minimum charge:** $280. Quarter-page, half-page and full-page display sizes are also available. To reserve your space, call Maria Bennett at (770) 431-0867, ext. 219, Fax (770) 432-6969, E-mail: bennett@lionhrtpub.com.

Send all material to:
Maria Bennett, Lionheart Publishing Inc.,
E-mail: bennett@lionhrtpub.com.

Call for Papers

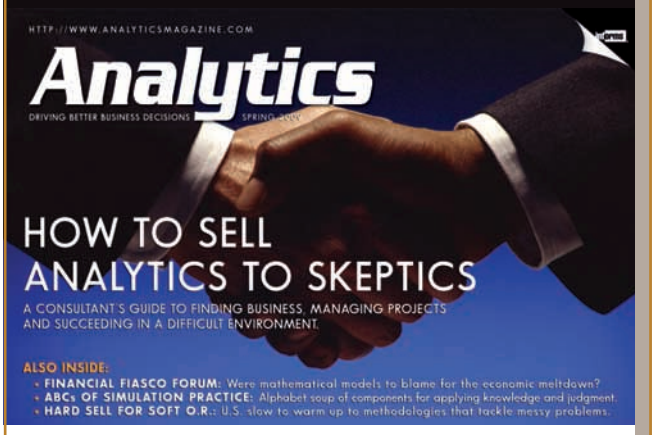
OPERATIONS MANAGEMENT RESEARCH:

Advancing Practice through Theory

The second issue of the new journal ***OMR***, published by Springer, has just been released and papers are now being solicited for the next volume. ***OMR***'s purpose is to fill the growing need for a peer-reviewed journal that publishes high-quality research that is shorter and more sharply focused than articles in existing OM journals and makes a clear contribution to both the theory and practice of OM. ***OMR*** has been designed as a rigorous, double-blind peer-reviewed journal that is oriented toward fast reviews and publication. All research methodologies and all topics in the field are welcome.

Initial submissions can be in any good academic style and format but are limited to 20 manuscript pages, including figures and tables. Manuscripts should be double spaced with 12 point font and one-inch margins. You should receive at least two reviews of the paper within 8 weeks and a decision suggested by the Area Editor. The comments from the AE will explain the decision, and if a revision is requested, how to revise the paper to make it acceptable for ***OMR.*** The Editors-in-Chief of the journal are Jack Meredith and Patrick McMullen, both of Wake Forest University. For more information, please see the web site **www.springer.com/12063,** as well as the weblink entitled "*Important Information for Authors*" at the submission site **www.editorialmanager.com/omra.**

New Issue of *ANAYLTICS* Now Available



www.analyticsmagazine.com

Check out the latest issue of *Analytics* and register for a free subscription

GET REAL!

Real World Operations Research: The Woolsey Papers

Edited by Richard L. Hewitt, Ph.D.

Real World Operations Research: The Woolsey Papers is a collection of the diverse writings of one of OR's most outspoken and controversial figures, Gene Woolsey. Woolsey's humorous and practical writings leave little wonder as to his venerable status in the field.

This collection contains 33 articles published from 1972 to 2003, covering a broad spectrum of subject matter relevant not only to OR/MS professionals, but also educators, managers and corporate administration. To accompany his writings on operations research, chapters also cover topics from communication in the corporate world to handling labor disputes, getting promoted and getting fired. Through creative storytelling and down-to-earth advice, Woolsey provides readers with the knowledge and philosophical mindset to conquer operations and management situations in all settings.

Order online at **www.lionhrtpub.com/books**
or call **1-888-303-5639, ext. 214.**

Real World Operations Research: The Woolsey Papers
By Robert E. D. Woolsey, Ph.D., F.I.D.S.
Edited by Richard L. Hewitt, Ph.D.
164 pages • 6 x 9 • paperback
ISBN: 1-931634-25-4
$19.95 (Plus $4.00 S&H US)

The Unsung Hero

BY DOUG SAMUELSON

"Really interesting, Warren," Anne, the IT manager, said as the waiter cleared the plates from the main course and brought dessert menus. "This 'soft O.R.' you asked me to read about does sound more useful than what you O.R. guys typically offer me. Maybe there is more you could do for us. But why don't we hear more about this less technical, more problem-focused part of the profession?"

"Beats me," the O.R. analyst shrugged. "It does get covered, but maybe not so much in the top archival journals. A few months ago I reviewed a draft article by a couple of Europeans who asked why O.R. is heavily used in government in most developed countries but not in the United States. Of course, it is used in the U.S.! I think the difference, though, is that in Europe it makes the big journals, especially *EJOR*, and here it's in *Interfaces,* some Edelman entries and *OR/MS Today* and publications outside the profession. Anyway, I'm glad you see the potential – that's why I schemed to get you out to lunch!"

"I wonder, though," Anne persisted, "what it says about O.R. here in the U.S. that good applications are so rare in the journals. I know when I have something to write about, I usually look at other publications, partly because it seems that good applications without mathematical sophistication don't have a chance. I'm OK with math myself, but it isn't necessary for every success story."

"True," Warren acknowledged, "but there actually is a reason journals go that way. Academics are strongly encouraged – in fact, required – to publish. Practitioners are often discouraged, as employers are concerned about protecting secrets, and they typically have to do the writing on their own time. So not only contributors but also referees tend to be academics. Everybody's busy, the more successful the more so, and it's a lot easier to decide whether something makes sense if it's expressed in clear, precise language. Math is the clearest, most precise language we have, so articles by people who have taken the trouble to state the problem and its solution mathematically get reviewed more quickly and evaluated more accurately. That's enough to produce the trend we see."

"It doesn't have to be that way," Anne objected. "Clear English isn't that hard to write, if you know what you're talking about."

"Harder than you think," Warren demurred, "and it's not just how clearly you write, it's how readily people understand it. Math requires more background and more effort, but then it's unambiguous. If you look at economics, there are plenty of issues that can be described and analyzed without math – but it's actually easier to present and follow with math. R. H. Coase, who got the Nobel Prize in 1991, made a point of never using equations, stating everything in wonderfully plain English. Sure enough, the value of his work got recognized – 30 years later! His big contributions were from the late 1950s and early 1960s."

"Black and Scholes did get recognized faster for their work on securities pricing," Anne agreed, "but apparently their work had some problems. Didn't Scholes turn a $4 billion investment fund into a $1 billion fund in about a year, not long after winning the Nobel?"

"Yeah," Warren laughed. "It seems they hit a situation outside the experience they'd estimated from. Solving the problem you started out with isn't always enough – or, in some cases, not necessary, either! Sometimes you have to look at the question they didn't ask, behind the one they did. Like the unsung hero of O.R."

"Who's that?" Anne inquired.

"Dick Larson, who's a professor at MIT and has been president of both ORSA and INFORMS, likes to tell the story of a young fellow who got sent to midtown Manhattan back in the 1950s. He thinks the guy was one of Russ Ackoff's students at Wharton, but nobody knows for sure – including Russ Ackoff, apparently, according to a couple of people who tracked him down and asked him about it. Whoever he was, it seems the management of this big office building was getting a lot of complaints about how long the elevators took to show up, and this guy was supposed to analyze the delays and see what could be done.

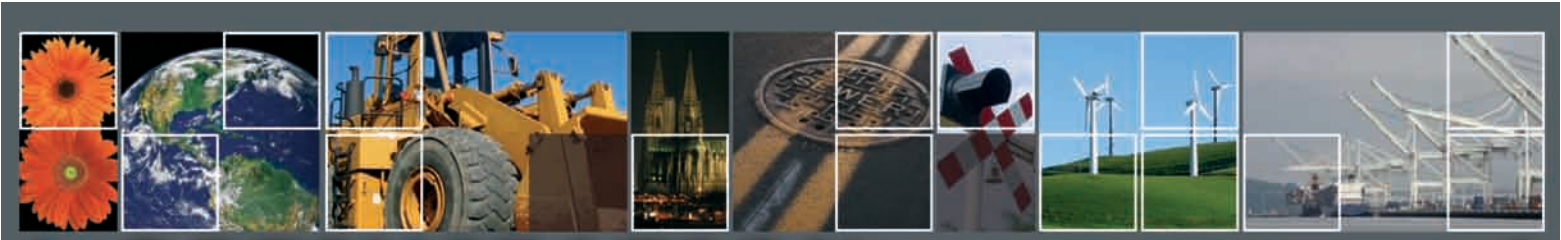
Math is the clearest, most precise language we have, so articles that state the problem and its solution mathematically get evaluated more accurately.

"It seems the elevators were working about as well as others in the area. There wasn't much he could see to do to improve the response times. He eventually realized, though, that the client's problem wasn't how long the delays were, it was how many people complained about them! He also noticed that most of the complaints were about how long people waited in the lobby for elevators going up, not so much about elevators coming down from higher floors. So he recommended putting mirrors in the ground-floor lobby, just to give people there something else to think about. The complaints decreased by about 80 percent, and the guy was a hero – not only with no math, but with no improvement on the problem they'd asked him to solve!"

"So did that story get into *Operations Research?*" Anne teased.

"Not even in the 1950s," Warren conceded with a rueful chuckle. "And it wouldn't make it as a Wagner Prize entry, either, much less an Edelman. But maybe we could entice someone to write it up for *OR/MS Today.* At least then we'd have a record of who he was, and some encouragement for other practitioners to ask that deeper question, as he did!" IORMS

Doug Samuelson *(samuelsondoug@yahoo.com) is president and chief scientist of InfoLogix, Inc., in Annandale, Va.*



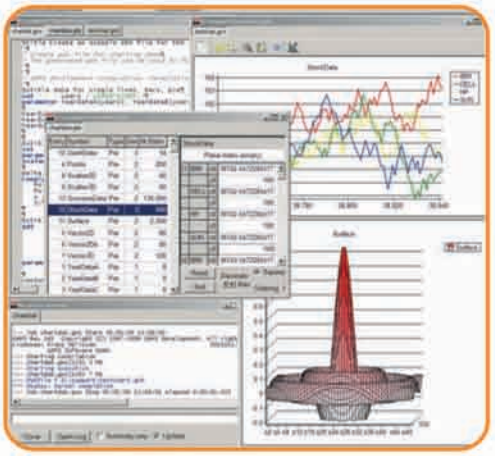
OPTIMIZATION

www.gams.com

GAMS

High-Level Modeling

The General Algebraic Modeling System (GAMS) is a high-level modeling system for mathematical programming problems. GAMS is tailored for complex, large-scale modeling applications, and allows you to build large maintainable models that can be adapted quickly to new situations. Models are fully portable from one computer platform to another.



GAMS Integrated Developer Environment for editing, debugging, solving models, and viewing data.

Wide Range of Model Types

GAMS allows the formulation of models in **many different problem classes**, including

- Linear (LP) and Mixed Integer Linear (MIP)
- Quadratic Programming (QCP) and Mixed Integer QCP (MIQCP)
- Nonlinear (NLP) and Mixed Integer NLP (MINLP)
- Constrained Nonlinear Systems (CNS)
- Mixed Complementary (MCP)
- Programs with Equilibrium Constraints (MPEC)
- Conic Programming Problems
- Stochastic Linear Problems

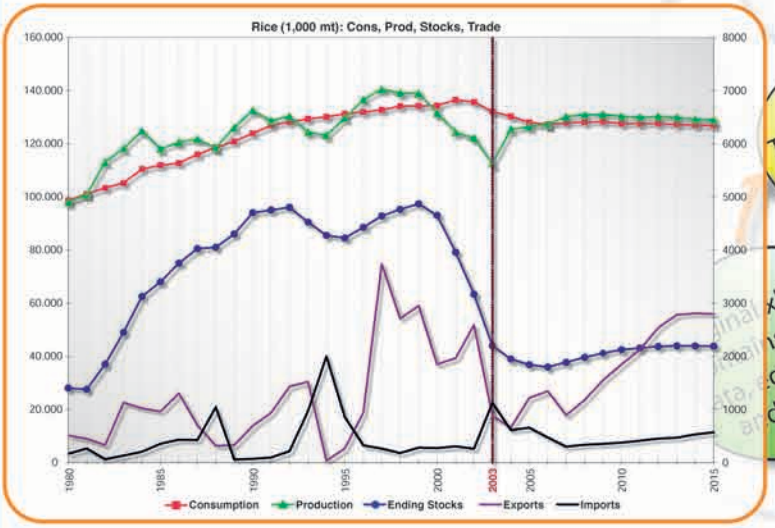
State-of-the-Art Solvers

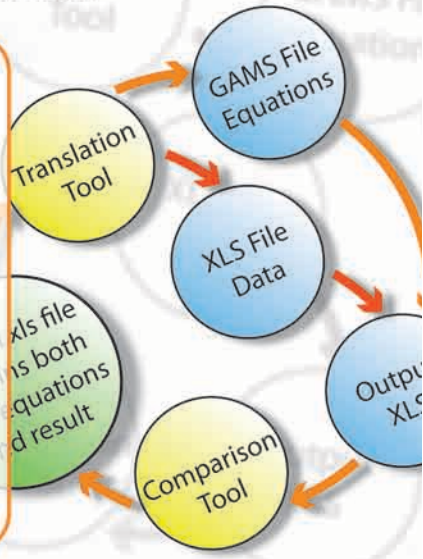
GAMS incorporates all major commercial and academic state-of-the-art solution technologies for a broad range of problem types, including global nonlinear optimization solvers.

The ERS/USDA China Agricultural Regional Model

The ERS/USDA China Agricultural Regional Model is a dynamic, multi-regional, partial equilibrium agricultural model with graphical tools. The highly non linear model is used to generate 10 year projections of supply, demand, trade, and prices for 24 commodities, 6 major producing regions in China as well as aggregate national level.

- First developments spread sheet based, now model moved to GAMS formulation
- Major parts of the GAMS code are generated automatically
- Automated exchange of data between GAMS and several spreadsheets for scenario analysis and reporting
- For more information about this model please contact: carm@gams.com





USA

GAMS Development Corporation

1217 Potomac Street, NW
Washington, DC 20007, USA

phone
+1-202-342-0180
fax
+1-202-342-0181
mail
sales@gams.com
web
http://www.gams.com

Europe

GAMS Software GmbH

Eupener Strasse 135-137
50933 Cologne, Germany

phone
+49-221-949-9170
fax
+49-221-949-9171
mail
info@gams.de
web
http://www.gams.de