

THE INSTITUTE OF
MANAGEMENT SCIENCES

NEWSLETTER OF THE
TIMS College
on
Simulation and Gaming

BARRY L. NELSON, EDITOR and DAVID GOLDSMAN, ASSISTANT EDITOR VOL. 11, NO. 1 SPRING 1987

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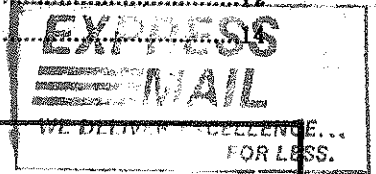
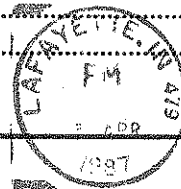
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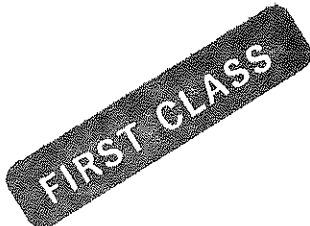
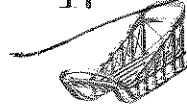
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CHAIRMAN'S MESSAGE

All members of the TIMS College on Simulation and Gaming can be proud of the presentation of the College's first Outstanding Service Award to John Mcleod at the 1986 Winter Simulation Conference. When the College decided to have an award specifically recognizing service, it was in response to the fact that "service to the profession" is typically discounted when a field honors its outstanding members.

This award gives service a special distinction and recognition separate from research, teaching, and practice. Teaching, research, software development, and applications are typically well rewarded. Most universities have teaching awards; most organizations (such as this TIMS College) have research awards. There are financial awards and recognition for excellence in industry, consulting, and applications in general. Those who devote their time and energy to service are too often ignored; even a simple "thank you" is sometimes neglected.

It is well that we recognize the many committee members, editors, referees, meeting organizers, session chairpersons, members of national boards, etc. This award implicitly honors all those whose selfless contribution of time and energy sustains our profession.

Respectfully submitted,
Lee Schruben
Chairman

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TREASURER'S REPORT

For the period 10/16/86 through 2/26/87 the College account had the following transactions, all at First Minnesota, Edina:

REVENUES:

Deposit of funds (from Jim Wilson, ex-Treasurer)	\$ 13,407.66
Interest earned	212.63
Profit share for WSC '85	965.00
Refund on WSC '86 advance	2000.00
Sale of WSC '86 <i>Proceedings</i>	255.00
Total	<u>\$ 16,940.29</u>

DISBURSEMENTS:

Fall '86 <i>Newsletter</i>	\$ 277.42
Pay off deficit at TIMS HQ	730.47
Reception at Miami ORSA/TIMS	65.05
College letterhead	14.84
Service Award plaques	\$ 37.45
Advance to WSC '87	2,000.00
Freight for WSC '86 <i>Proceedings</i>	\$ 78.75
Best paper award and plaque	530.42
Total	<u>\$ 3,734.40</u>

NET (Revenues - Disbursements) (As of 2/26/87) \$ 13,205.89

Profit shares from WSC '86 are expected soon, but have not been as yet been received. All funds are in a "Supernow" money market checking account at First Minnesota, since the rates on certificates are currently very low.

Respectfully submitted,
W. David Kelton
Treasurer

MINUTES OF COLLEGE MEETING AT MIAMI
ORSA/TIMS CONFERENCE

Held: Friday, October 23, 1986, 5:00 p.m. at Fountainebleau Hilton Hotel

Present: Sewa Awad, S. Balachandram, Robert Barrett, Sen-Shung Chou, Dave Goldsman, Jorge Haddock, Don Hommertzhaim, Alf Jones, Keebom Kang, T.J. Wang, Jim Wilson, Dave Withers

College Vice-Chairman, Jim Wilson, called the meeting to order.

1. The Minutes of the meeting at Los Angeles TIMS/ORSA Conference were approved as distributed in the *Newsletter* (Fall, 1986).
2. Jim Wilson presented the Treasurer's Report. He also reported the status of the *Proceedings of 1986 Winter Simulation Conference*.
3. A motion was made by Dave Withers and seconded that the College act as a broker to distribute the WSC *Proceedings* to students at close to cost. The motion carried.
4. Jim Wilson reported that the Fall *Newsletter* was published in the School of Industrial Engineering, Purdue University, at a cost of \$266.00. This was a follow-up of the discussion at LA TIMS/ORSA conference, and resulted in a substantial saving to the cost of \$600.00 charged by the TIMS Headquarters.
5. Dave Withers, the Chairman of the Publication Award Committee, discussed the method of presenting the award during the conference. It was also suggested to announce the award in *OR/MS Today* and *Simletter*. Further discussion was deferred until the Spring meeting.
6. Jorge Haddock questioned simulation sessions in Spring meetings. A motion was made by Alf Jones and seconded that the College should maintain at least one college-sponsored session with invited papers during the Fall conference. The motion carried.
7. Jim Wilson announced the TIMS/CSG Mixer at 6:30 p.m. in Jorge Haddock's room.
8. Jim Wilson adjourned the meeting at 5:35 p.m.

Respectively submitted,
Keebom Kang
(for David Kelton)

MINUTES OF TIMS COLLEGE ON SIMULATION
AND GAMING BUSINESS MEETING

Held: Tuesday, December 9, 1986, 6:30 p.m. at 1986 Winter Simulation Conference

Present: Jorge Haddock, John Gardenier, Barry Nelson, Andy Seila, Whey Ming Tina Song, Bruce Schmeiser, Steve Kammerer, Lance Heiko, Chuck White, Merriel C. Dewsnup, Connie Busch, Steve Ainey, John Carson, Dave Goldsman, Michael Samuels, Gordon Clark, Robert Sargent, Alan Pritsker, Jim Wilson, David Kelton, Jim Swain, Paul Sanchez, Ben Fox, Lee Schruben (Chairperson).

The meeting was called to order by Chairman Lee Schruben.

1. A discussion was held concerning the recent decision not to sponsor sessions at the Fall ORSA/TIMS meeting due to its temporal proximity to the WSC. Sentiment was expressed to resume such sponsorship at a fairly low level (perhaps only one session) to service interested parties who might still want to attend the meeting (e.g., due to spatial proximity), as well as to clarify that not any session at the Fall ORSA/TIMS meetings with "Simulation" in the title carries the endorsement and sponsorship of the College. A motion to sponsor at least one session at both the Fall ORSA/TIMS Conference and the Spring TIMS/ORSA Conference was made and passed unanimously.
2. Attendees at the meeting identified themselves and their affiliations.
3. Alan Pritsker, the College representative to the WSC Board, indicated that there was a large representation of College members in the organization of WSC '86, including Bruce Schmeiser (even though he is on the Board representing another society), Jim Henriksen, Steve Roberts, Jim Wilson, Hank Grant, and David Kelton. He then raised the issue of whether a *Proceedings* paper of minimal length should be required in order to present a talk at the WSC (with the exception of panels), and specifically whether the WSC Board should allow the Conference Committee each year to make this decision; he noted that this year there was essentially 100% participation in the *Proceedings* by WSC presenters. A discussion of his issue ensued, during which the additional issue of whether such a rule should be applied to the Keynote Speaker. General support for the general requirement was voiced noting difficulties in enforcement and tardiness. Alan proposed that the Program Chair should make a decision as to whether research results would be acceptable in the form of brief abstracts. Also, the *Proceedings* could be augmented with reviews, and short position statements of panel participants; the possibility of transcribing the keynote speech was raised. Alan then summarized the financial arrangements of the WSC, noting the \$2000 advance from each sponsor, including the College. Finally, he thanked this year's committee, noting the large attendance of around 540.
4. Jim Wilson, College Vice-Chairman, reported on session sponsorship at the 1987 Spring TIMS/ORSA Conference in New Orleans, noting that six sessions will be sponsored.
5. David Kelton, College Secretary-Treasurer, reported a balance of \$13,347.43 in the College treasury, and expressed embarrassment at the large amount and a desire for good ideas on how to spend some of the money.
6. Lee Schruben, College Chairman, summarized the status of the By-Laws and Awards Committees.

7. Gordon Clark, a member of the College Best Publication Award Committee, reported on the Committee's status. A discussion ensued on the issue of on-the-job development of criteria as well as how to pay for books that might be nominated. Alan Pritsker suggested writing to publishers for free copies of books. Bruce Schmeiser moved that the committee members be reimbursed for expenses, which passed unanimously.
8. Bob Sargent raised the issue of embarrassingly low attendance at sessions involving subjects that are a bit outside the "usual" fare in simulation, citing ranking/selection and time series as examples. Lee Schruben suggested the idea of "designated special" sessions to call attention to them. John Gardenier reported that other conferences set aside a particular time slot for innovative sessions, thereby avoiding time conflicts to some extent. The Program Chair for WSC '87 took note of these ideas.
9. Finally, a discussion was held on possible ways to spend some of the College's wealth. Bob Sargent suggested inviting Ph.D. students to interact at WSC's. Tom Clark suggested a student paper competition. Lee Schruben suggested having Ph.D. students invited to present their ideas informally at WSC's before faculty from other institutions for the purpose of informal feedback and suggestions. Bruce Schmeiser suggested providing WSC *Proceedings* to students at cost. Bob Sargent suggested buying WSC *Proceedings* to place in university departments. Alan Pritsker suggested buying WSC *Proceedings* and giving them to student attendees of the WSC; Andy Seila pointed out that this may discriminate against students who may not be able to attend the WSC. Bruce Schmeiser moved to continue to provide WSC *Proceedings* to students at cost. Alan Pritsker moved to table the motion, and this motion was passed unanimously.
10. The meeting adjourned at 7:35 p.m.

Respectfully submitted,
David Kelton
Secretary

WSC '86 PROCEEDINGS AVAILABLE FOR STUDENTS

In accordance with a motion passed at our Fall meeting in Miami, we have obtained a *limited* number of copies of the *Proceedings of the 1986 Winter Simulation Conference* so that we may offer them for sale to students or student organizations. The price is \$35.00, and checks should be payable to TIMS/College on Simulation and Gaming. (The standard price set by other sponsors of WSC is about \$75.00.) Please include a certification of student status signed by a faculty member. The cutoff date for orders is *May 15, 1987*. Send the check and certification statement to:

James R. Wilson
School of Industrial Engineering
Purdue University
West Lafayette, IN 47907

TIMS/CSG OUTSTANDING SERVICE AWARD CALL FOR NOMINATIONS

The second TIMS/CSG Outstanding Service Award, to recognize longstanding, exceptional service to the simulation community, will be presented next fall. Nominations for the award must be received by the chairman of the Award Committee by September 1, 1987: Professor William E. Biles, Chairman, Department of Industrial Engineering, Louisiana State University, Baton Rouge, LA 70803; Telephone: (504) 769-5112.

The rules governing the Award were printed in Vol. 9; No. 2 (1985) of the *Newsletter*. In short, anyone may nominate any person without restriction, and the burden of offering evidence of merit falls on the nominator. Questions should be directed to the Chairman of the Award Committee.

TIMS/CSG OUTSTANDING SIMULATION PUBLICATION AWARD CALL FOR NOMINATIONS

The second TIMS/CSG Outstanding Simulation Publication Award, to recognize outstanding contributions to the simulation literature, will be presented at the Spring 1988 TIMS/ORSA Joint National Meeting. Nominations for the Award must be received by the chairman of the Award Committee by September 1, 1987: Professor Gordon M. Clark, Department of Industrial and Systems Engineering, 1971 Neil Avenue, The Ohio State University, Columbus, OH 43210; Telephone: (614) 292-7863.

The rules governing the Award were printed in Vol. 9, No. 2 (1985) of the *Newsletter*. In summary, anyone is eligible to win the award. Journal articles, proceedings articles, books and monographs copyrighted in the last three years are eligible; technical reports, research memoranda, working papers, and dissertations/theses are not eligible. Nominations can be made by anyone, including the author(s). Nominations may not be anonymous and shall include: (a) a copy of the written work including bibliographical information (in the case of books, the Award Committee will obtain copies), (b) a short statement suitable for reading at the award ceremony if the work is chosen, and (c) any other information thought relevant by the nominator.

ABSTRACTS OF PAPERS

Jeffrey D. Tew
James R. Wilson
School of Industrial Engineering
Purdue University
West Lafayette, IN 47907

"Validation of Correlation-Induction Strategies for Simulation Experiments," Research Memorandum No. 86-12, School of Industrial Engineering, Purdue University.

This paper develops a three-stage statistical procedure for validating the use of the Schruben-Margolin correlation induction strategy together with the follow-up analysis of Nozari, Arnold and Pegden (1986) in a simulation experiment designed to estimate a general linear model for the simulation response. Each stage of the procedure tests a key assumption about the behavior of the response across all points in the design. The first stage tests for multivariate normality, the second stage tests for the induced covariance structure postulated by Schruben and Margolin, and the third stage tests for the adequacy of the proposed linear model. Because the test in each stage presupposes the properties tested at the previous stages, these diagnostic checks on the experimental design and analysis must be performed in the indicated order.

Keebom Kang
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University of Miami
Coral Gables, FL 33124

Bruce Schmeiser
School of Industrial Engineering
Purdue University
West Lafayette, IN 47907

"Methods for Evaluating and Comparing Confidence-Interval Procedures," Technical Report, Department of Industrial Engineering, University of Miami.

Coverage contours and scatter diagrams, designed as tools for evaluating and comparing confidence-interval estimation procedures, are developed. The contours combine the ideas of the power function and the coverage function; both the expected width and the probability of coverage appear in one figure. Scatter diagrams, which exhibit the variability of confidence intervals, are developed to supplement the coverage contours and as an evaluation tool in their own right.

Ward Whitt
AT&T Bell Laboratories
Holmdel, NJ 07733

"Simulating Brownian Motion and Other Random Objects."

It is apparent that there can be difficulties simulating Brownian motion by discrete-event digital simulation, but surprisingly in some sense it is no more difficult to simulate Brownian motion than a single uniform random variable. This paradox leads us to examine more carefully what is meant by the complexity of a stochastic simulation. A definition of complexity for generating random objects is proposed that avoids various paradoxes of the infinite by recognizing the essential role of approximation. The complexity of a scheme for simulating a probability measure is defined in terms of an appropriate distance between that probability measure and an approximation of it generated from a specified number of Bernoulli random variables. Given a metric and a specified accuracy, the complexity can thus be measured in Bernoullis. With this definition, it is possible to quantify the complexity of a stochastic simulation, e.g., to see that it is indeed much more difficult to simulate Brownian motion of a finite interval than a single uniform random variable: With standard constructions based on n Bernoulli random variables, the Prohorov distances are of order $n^{-1/2}$ and 2^{-n} , respectively.

Y.V. Ramana Reddy
Mark S. Fox
Nizwer Husain
Carnegie Mellon University

Malcolm McRoberts
McDonnell Douglas Astronautics

"The Knowledge-Based Simulation System," *IEEE Software Engineering of Knowledge-Based Systems*, March 1986.

Knowledge-Based Simulation is an approach which combines Artificial Intelligence knowledge representation, object programming and problem solving techniques into a general discrete event simulation system. As such, complex systems may be more easily modeled and embedded expertise can be used to design, execute and analyze simulation experiments automatically. The paper uses a Corporate Distribution System model to illustrate salient features of KBS, with due emphasis given to validation of causal hypotheses which are then used to quantify rules that diagnose simulation output and generate goal-directed scenarios.

Ward Whitt
AT&T Bell Laboratories
Holmdel, NJ 07733

"Planning Queueing Simulations"

This paper develops simple heuristic formulas to estimate the data required to achieve desired statistical precision in queueing simulations. The formulas are intended to help in the early planning stages before any data have been collected. The queueing simulations considered are single replications (one long run) conducted to estimate steady-state characteristics such as expected equilibrium queue lengths. The formulas can be applied to design simulation experiments to develop and evaluate queueing approximations. In fact, this work was motivated by efforts to develop approximations for packet communication networks with multiple classes of traffic having different service characteristics and bursty arrival processes. In addition to indicating the approximate sample size required in each case of a designed experiment, the formulas can help determine what cases to consider, what statistical precision to aim for, and even whether to conduct the experiment at all. The formulas are based on heavy-traffic limits for queues (the limiting behavior as the traffic intensity approaches its upper limit for stability) and associated diffusion approximations.

Peter W. Glynn
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Ward Whitt
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"Indirect Estimation via $L = \lambda W$ "

For a large class of queueing systems, Little's Law ($L = \lambda W$) helps provide a variety of statistical estimators for the long-run time-average queue length L and the long-run customer-average waiting time W . We apply central-limit-theorem versions of Little's Law to investigate the asymptotic efficiency of these estimators. The asymptotic efficiency is important because it determines the size of confidence intervals with large samples. The central-limit-theorem versions of $L = \lambda W$ are important because they relate the asymptotic efficiencies of the estimators and because they hold in almost the same level of generality as Little's Law itself. In this setting, we show that an indirect estimator for L using the known arrival rate λ and Little's Law is more efficient than a direct estimator for L , provided that the interarrival times and waiting times are negatively correlated, thus extending a variance-reduction principle for the GI/G/s model due to Law [1975] and Carson and Law [1980]. However, when λ is estimated too, no advantage in asymptotic efficiency is gained from Little's Law. We also introduce a general framework for indirect estimation which can be applied to other problems besides $L = \lambda W$. The issue of indirect-versus-direct estimation can be related to estimation using nonlinear control variables. We also show, under mild regularity conditions, that a nonlinear control-

variable scheme is equivalent to a linear control-variable scheme from the point of view of asymptotic efficiency. Optimal linear control-variable estimators for L and W exploiting a known arrival rate λ are thus more asymptotically efficient than the direct and indirect estimators in the $L = \lambda W$ framework. Since linear-control estimators are easy to construct, they are recommended for estimating L and W whenever quantities such as λ are known in a large-sample context. We also consider asymptotic bias and show that it is typically asymptotically negligible compared to asymptotic efficiency.

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"The Efficiency of Simulation Estimators"

A decision-theoretic framework is proposed for evaluating the efficiency of simulation estimators of steady-state descriptions of a stochastic model. The framework includes the cost of obtaining the estimate as well as the cost of acting based on the estimate. The cost of obtaining the estimate and the estimate itself (e.g., a sample mean) are represented as realizations of jointly distributed stochastic processes. In this context, the efficiency of a simulation estimator based on a given computational budget is defined as the reciprocal of the risk (the overall expected cost). Limit theorems are established for this model as the experimental budget increases that support and extend a fairly well-known efficiency principle, proposed by Hammersley and Handscomb (1964), p. 22:

The efficiency of a Monte Carlo process may be taken as inversely proportional to the product of the sample variance and the amount of labour expended in obtaining this estimate.

In the proposed efficiency principle, the "amount of labour expended" is replaced by an appropriate power of the long-run average cost of obtaining the estimate per unit length of the experiment and the "sampling variance" is replaced by the limit of the normalized expected cost of acting based on the action, without considering the cost of obtaining the estimate. The Hammersley and Handscomb principle is usually (but not always) obtained as a special case of this new asymptotic efficiency principle when the cost of acting based on the estimate is the classical squared error.

Ardavan Nozari
Salomon Brothers, Inc.
New York, NY 10004

Ward Whitt
AT&T Bell Laboratories
Holmdel, NJ 07733

"Estimating Average Production Intervals Using Inventory Measurements"

This paper proposes an indirect approach for estimating average production intervals using work-in-process inventory measurements. The idea is to apply a modified version of Little's Law ($L = \lambda W$) from queueing theory to cope with stochastic processes that are not directly observable. When the actual amount of completed product that will eventually be produced from current work in process is not known, we suggest working with an appropriate expected amount of completed product associated with current work in process, taking care to properly account for such features as partial yields, changing lot sizes and reconstituted lots. This indirect estimation procedure can be applied with computer simulation as well as direct system measurement. The approach can also be used to calculate expected values of steady-state random variables.

NEW BOOKS

Jack P.C. Kleijnen (1986), *Statistical Tools for Simulation Practitioners*, Marcel Dekker, NY.

Chapters: Runlength and Confidence Intervals; Regression Analysis; Experimental Design.

Reuven Y. Rubinstein (1986), *Monte Carlo Optimization, Simulation and Sensitivity of Queueing Networks*, Wiley, NY.

Chapters: Antithetic and Common Random Variables in Simulation of Complex Stochastic Systems; Multidimensional Control Variates in Monte Carlo Simulation; Stochastic Optimization via Stochastic Approximation; Perturbation Analysis for Sensitivity and Optimization of Complex Queueing Networks; Monte Carlo Optimization.

EVENT CALENDAR

TIMS/ORSA Joint National Meeting, May 4-6, 1987, New Orleans, Louisiana. Contact William E. Biles, Industrial Engineering Department, Louisiana State University, Baton Rouge, LA 70803; Telephone: (504) 388-5112.

The TIMS/CSG will be sponsoring sessions on: Statistical Analysis (W.D. Kelton), Simulation Optimization (G.M. Clark), Variate Generation (J. Gentle), Design and Analysis of Simulation Experiments (P. Sanchez), Simulation Graphics (J. Banks), and Variance Reduction (B. Schmeiser).

1987 Eastern Simulation Conferences, April 6-9, 1987, Orlando, Florida. Contact The Society for Computer Simulation, P.O. Box 17900, San Diego, CA 92117; Telephone: (619) 277-3888.

IASTED Applied Simulation and Modeling Conference, May 27-29, 1987, Santa Barbara, CA. Contact The Secretary, ASM '87, IASTED, P.O. Box 25, Station "G", Calgary, Alberta Canada T3A 2G1.

Workshop and Short Course on Stochastic Networks, June 15-26, 1987, University of Wisconsin - Madison. Contact T. Kurtz, Department of Mathematics, University of Wisconsin, 480 Lincoln Drive, Madison, WI 53706.

IASTED Identification, Modeling and Simulation, June 22-24, 1987, Paris, France. Contact The Secretary, IMS '87, IASTED, P.O. Box 354, CH-8053, Zurich, Switzerland.

European Simulation Multiconference, July 8-10, 1987, Vienna, Austria. Contact European Simulation Office, c/o Philippe Geril, University of Ghent, Coupure Links 653, B-9000 Ghent, Belgium.

1987 Summer Computer Simulation Conference, July 27-30, 1987, Montreal, Canada. Contact The Society for Computer Simulation, P.O. Box 17900, San Diego, CA 92117; Telephone: (619) 277-3888.

IASTED Applied Identification, Modeling and Simulation, November 11-13, 1987, New Orleans, LA. Contact Dr. R. Trahan, Chairman of AIMS '87, Department of Electrical Engineering, University of New Orleans, New Orleans, LA 70148.

Twenty-first Annual Simulation Symposium, March 16-18, 1988, Tampa, Florida. Contact Tom Kubiak, Decision Technologies Division - EDS, 803 W. Big Beaver Road, Troy, MI 48007.

The 5th Biennial Conference of the Applied Probability Group on Analysis and Control of Large Scale Stochastic Systems, May 23-25, 1988, Chapel Hill, NC. Contact V.G. Kulkarni or S. Stidham, Curriculum in Operations Research and Systems Analysis, University of North Carolina, Chapel Hill, NC 27514; Telephone: (919) 962-6997.

EDITOR'S CORNER

As a service to the members of the TIMS/CSG, the *Newsletter* will publish a directory of electronic-mail addresses of all interested (and willing) members. Send your electronic address to me at either

ts3816@ohstvma.bitnet

or

nelsonb@osupyr.uucp

I will respond electronically when I receive your message. If you are on a network that does not have a gateway to bitnet or uucp, send me your address via U.S. mail.

Many of us have developed software support libraries for simulation research and practice; for example, I have coded Schmeiser and Lal's bivariate gamma generator in FORTRAN (a nontrivial task!). With little budget and no staff, the *Newsletter* cannot act as a clearinghouse for such code. However, the *Newsletter* will publish a list and description of available routines. If you have software that you would be willing to make available to members of the TIMS/CSG at no cost, send a description of the software, including the language in which it is written, to either of the *Newsletter* editors for publication in later issues.

Barry L. Nelson
Newsletter Editor