THE INSTITUTE OF MANAGEMENT SCIENCES

NEWSLETTER OF THE
TIMS COLLEGE on SIMULATION AND GAMING

DAVID KELTON and JOHN CARSON, CO-EDITORS

VOL. 8, NO. 2 SPRING 1984

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*Cast your vote and return mail ballot as indicated on page 14.

COLLEGE ON SIMULATION AND GAMING
THE INSTITUTE OF MANAGEMENT SCIENCES
146 WESTMINSTER STREET
PROVIDENCE, RI 02903

FIRST CLASS

CHAIRMAN'S MESSAGE

The TIMS College on Simulation and Gaming enjoys a vigorous state of health as we near the end of the term for the present slate of officers, but this healthy state has actually persisted for some time now. The TIMS office has recently evaluated all colleges and chapters and pronounced our college as one of the strong and productive units. Some of the positive aspects of the Simulation College - -

- We charge $2 dues for our members
- Membership ranges from 250-320
- We assist in sponsoring the Winter Simulation Conference
- We produce two newsletters per year
- We give a "best paper" award
- We sponsor at least six sessions per year in annual conferences
- We have a healthy treasury
- We hold three business meetings per year

You have before you a very "busy" newsletter, with a very important ballot for your use. Please participate in the election of new officers.

This election represents our attempt to respond to your clamor for a truly contested election, but with one effort to maintain continuity: that is, the elected Vice-Chairman is also Chairman-Elect. I believe the nominating committee consisting of Bob Sargent, Averill Law and myself have presented an outstanding slate of candidates. So please participate in this election.

Also before you is a document describing the selection of recipient of a service award for the TIMS College on Simulation and Gaming. We expect to present the first such service award next year.

Several significant challenges confront the next cadre of officers, whomever they might be. There is a real need to better document the operations of the College, to clearly delineate all the duties of the various elected and appointed officers, and to record the achievements of the College. But most of all we must find ways to involve more of you in active roles in the College. The resources of talent and energy that remain untapped are sufficient to make the TIMS College on Simulation and Gaming one of the best organizations in TIMS. Please start by participating in the ballot before you.

William E. Biles
Chairman

BIOGRAPHIES OF CANDIDATES FOR COLLEGE OFFICES

Below are brief biographical sketches of the candidates for the College offices of Chairman, Vice-Chairman (who will henceforth be chairman-elect), and Secretary-Treasurer. Note that for this election only, a write-in vote for Chairman will be accepted. The ballot appears on the last page of this issue of the **Newsletter**, which you should tear off, mark, and send in according to the instructions there.

Chairman:

Bruce Schmeiser is Associate Professor in the School of Industrial Engineering at Purdue University. Previously he was on the faculty of Southern Methodist University. His Ph.D. is in Industrial and Systems Engineering from Georgia Tech. He is Simulation Department Editor for **IIE Transactions**, is on the editorial board of **Communications in Statistics**, has served on the editorial boards of several other journals, and is Vice-President of the College. His research interests are in the probabilistic and statistical aspects of digital computer simulation, and has published papers in **Communications of the ACM, JASA, Operations Research, IIE Transactions, Communications in Statistics**, and other journals.

Vice-Chairman and Chairman-Elect:

John S. Carson II is Assistant Professor of Industrial and Systems Engineering at the Georgia Institute of Technology. He is also active as a consultant to several major corporations. He received a Ph.D. in Industrial Engineering from the University of Wisconsin. His academic interests are in the area of statistical methodology applied to simulation. His applied interests are in the use of modeling and simulation applied to operations and manufacturing management. His research papers have appeared in **Operations Research**, the **SIAM Journal of Computing**, and numerous proceedings. He is co-author of the text, **Discrete-Event System Simulation.**(Prentice-Hall, 1984). He is a member of ORSA and TIMS.

Lee Schruben is an Associate Professor in the School of Operations Research and Industrial Engineering at Cornell University. He received a B. S. degree from Cornell in 1968, a M. S. from the University of North Carolina in 1972, and a Ph.D. from Yale in 1975. Schruben has long been active in the TIMS College on Simulation and Gaming. For four years he served as Co-editor of the College Newsletter and is presently Secretary/Treasurer for the College.

Prior to coming to Cornell, Schruben was at the University of Florida in Gainesville, Florida. In 1982-83 he was a visiting faculty member in the School of Industrial Engineering at Purdue. His current research is the design and analysis of simulation experiments and his practice is in manufacturing system simulation. He is an associate editor of **Operations Research, Operations Research Letters,** and **Simulation** and a member of TIMS, ORSA, and SCS.

Secretary-Treasurer:

David Kelton is Assistant Professor of Industrial and Operations Engineering at the University of Michigan. He received his Ph.D. in Industrial Engineering from the University of Wisconsin in 1980. His research interests are in the statistical and probabilistic methodology of simulation, stochastic models, and statistical inference on estimated stochastic processes. He has published papers in **Management Science, Operations Research, Naval Research Logistics Quarterly, Networks, Communications in Statistics,** and in other journals. He co-authored the book **Simulation Modeling and Analysis** (McGraw-Hill, 1982), with Averill Law. He has co-edited the College's **Newsletter** for the past three years.

James R. Wilson is currently an Assistant Professor in the Mechanical Engineering Department of the University of Texas at Austin; effective January 1, 1985, he will be an Associate Professor in the School of Industrial Engineering at Purdue University. He received a B. A. in mathematics from Rice University in 1970 and M. S. and Ph.D. degrees in industrial engineering from Purdue in 1977 and 1979 respectively. He has been involved in various systems analysis studies while working as a research analyst for the Houston Lighting and Power Company (1970-72) and while serving as a U. S. Army officer (1972-75). His current research interests include variance reduction techniques, ranking and selection procedures, and sequential stopping rules.

PROPOPOSAL FOR A SERVICE AWARD

TIMS College on Simulation and Gaming

1. Purpose of the Award: Recognize long standing, exceptional service to the Simulation Community.

2. Name of the Award: Award for Outstanding Contribution to the Field of Simulation (hereafter called the Award).

3. Form of the Award: a Plaque inscribed with the name of the award, the year awarded, and the name of the recipient.

4. Funding: The plaque will be purchased with funds from the treasury of the TIMS College on Simulation and Gaming. No expenses other than the cost of obtaining the plaque will be paid by the College. There is no cash prize associated with the Award.

5. Procedure:

   a. Announcement: A call for nominations will be widely published by the TIMS College Newsletter Editor in the first six months of each year.

   b. Nomination: Any person may nominate any person for the Award without restriction. The burden for offering evidence of merit falls on the person making the nomination. Nominations for a given year will be closed by September 1 of that year.

   c. Selection:

      i) A selection committee consisting of three members shall be appointed by the Chairman of the TIMS College on Simulation and Gaming to serve for one year.

      ii) Selection Committee membership shall be offered to all past Chairmen of the TIMS College on Simulation and Gaming and to all past recipients of the Award before other persons are offered membership.

      iii) The College Chairman will appoint one of the Selection Committee members as Selection Committee Chairperson who will have full responsibility for obtaining and presenting the plaque and for arranging significant publicity of the Award for that year.

iv) The Selection Committee will make the final decision of who will receive the Award by majority vote.

v) The Selection Committee is free to base their decision on any criteria.

vi) The Selection Committee may choose to make no Award in a given year.

vii) The Selection Committee is to make every reasonable effort to keep the names of nominees other than that of the Award winner confidential.

viii) The Selection Committee is not to make any other awards in the name of the TIMS College on Simulation and Gaming. Specifically, no "honorable mention" of unsuccessful nominees will be made.

d. Presentation: The Selection Committee Chairperson shall arrange for a suitable presentation of the Award at a national or international conference of which TIMS is a sponsor. No travel expenses associated with presenting the Award will be paid by the TIMS College on Simulation and Gaming either to the Selection Committee Chairperson or to the recipient of the Award. The presentation is to be made sometime during the last three months of the year in which it is awarded, if possible.

e. Default: The Chairman of the TIMS College on Simulation and Gaming may dissolve the Selection Committee at any time for cause. Such action by the College Chairman may be protested by the chairperson of the Selection Committee and the decision to dissolve the committee subjected to a vote of the College membership at the Selection Committee Chairperson's discretion. If the Selection Committee is dissolved, the College Chairman shall appoint another Selection Committee according to the above procedure. The new Selection Committee will then have the full powers of the former Selection Committee.

1982 BEST PAPER AWARDS

The College's vote for the best paper dealing with a simulation topic to appear in 1982 in **Management Science** resulted in a tie between two papers, "A Renewal Theoretic Approach to Bias Reduction in Regenerative Simulations" by Marc Meketon and Philip Heidelberger, and "Confidence Intervals for Steady-State Simulations, II: A Survey of Sequential Procedures" by Averill Law and David Kelton. The voting was by the College membership from a group of five nominated papers, as listed in the Spring 1983 edition of the **Newsletter**. Each of the four authors received a plaque and $125 at the awards ceremony during the Fall 1983 ORSA/TIMS meeting in Orlando.

1983 BEST PAPER NOMINATIONS

Fewer than three nominations were received for the College's award for best paper dealing with simulation appearing in Vol. 29 (1983) of **Management Science**. Thus, per the notice of the award's institution in the Fall 1980 edition (Vol. 4, No. 3) of the **Newsletter**, the prize will not be offered, and those papers nominated from Vol. 29 (1983) of **Management Science** will remain eligible for next year's award, which covers Vol. 30.

CALL FOR NEWSLETTER CONTRIBUTIONS

The deadline for the Fall 1984 edition of the **Newsletter** is September 1, 1984. Please send us materials, including abstracts of technical reports, announcements of new books, short courses (please see Editors' note in the "Short Courses" section of this issue), conferences, moves, research or applications questions, or any other items you feel may be of interest to other members of the College. Our addresses are:

David Kelton
Dept. of Industrial and
Operations Engineering
The University of Michigan
Ann Arbor, Michigan 48109
(313)-763-1412

John Carson
School of Industrial and
Systems Engineering
Georgia Institute of Technology
Atlanta, Georgia 30332
(404)-894-2308

NEWS

Jack P. C. Kleijnen will be visiting Pritsker & Associates during the period June 28, 1984 to August 15, 1984. He will teach a one-week seminar based on his forthcoming book "Statistical Tools for Simulation Practitioners" and will engage in research on Decision Support Systems. His address will be: Dr. Jack P. C. Kleijnen, c/o Pritsker & Associates, Inc., P. O. Box 2413, West Lafayette, Indiana 47906, (317)-463-5557.

Bruce Schmeiser is at Bell Labs for the summer, and can be reached c/o Marc Meketon, Room 4K-434, ATT Bell Labs, Holmdel, NJ 07733, (201)-949-0845.

MINUTES OF COLLEGE MEETING AT ORLANDO ORSA/TIMS CONFERENCE

Attending: Jeff Arthur, Chacko Abraham, Ed Mykytka, David Withers, David Goldsman, Robert Sargent (Syracuse), Gordon Clark (Ohio State Univ.), Andy Andrews (Univ. of Mich.), David Kelton (Univ. of Mich.), Thomas Schriber (Univ. of Mich.), Mike Overstreet (Univ. of Alabama), Bruce Schmeiser (Purdue), and Lee Schruben (Cornell).

College Vice Chairman, Bruce Schmeiser called the meeting to order.

Charles Harvey interrupted the meeting to pick up an umbrella.

1. Vice Chairman, Bruce Schmeiser, said that the college will be sponsoring three sessions at the San Fransisco ORSA/TIMS meeting and two sessions at the international TIMS meeting in Denmark this summer.

2. Robert Sargent moved that a committee be appointed by the chairman to draft a proposal for the College Service Award. This was seconded and passed by unanimous vote.

3. Research funding was discussed and Gordon Clark suggested that the college sponsor a session on research funding at some future conference. This motion was seconded and passed by unanimous vote.

4. Robert Sargent suggested that we include papers from any journal in the College award for best paper. Currently only papers in **Management Science** are considered. This will be an agenda item at a future meeting.

5. David Withers asked about the College volunteering session chairpersons for the contributed sessions at ORSA/TIMS meetings. It was agreed with two abstentions that the College ahould continue to support the contributed sessions in some way.

Lee Schruben suggested that rather than sponsor three or four sessions at each of the two annual ORSA/TIMS meetings we should consider sponsoring seven or eight sessions at only one meeting and not sponsor sessions at the other. Bruce Schmeiser said this was a "good point" and adjourned the meeting.

r. s.
Lee Schruben (Secretary)

MINUTES OF COLLEGE MEETING AT 1983 WINTER SIMULATION CONFERENCE

Attending college members: Marc Meketon (ATT Bell Labs), Alan Pritsker (P and A), George Fishman (Univ. of N. Carolina), Robert Sargent (Syracuse), Andrew Seila (Univ. of Georgia), Ronald Dattero (Texas A&M), Osman Balci (Virginia Tech), Jerry Richards (NC State Univ.), Gordon Clark (Ohio State Univ.), Dennis Smith (Desmatics), Andy Andrews (Univ. of Mich.), David Kelton (Univ. of Mich.), Thomas Schriber (Univ. of Mich.), Bruce Schmeiser (Purdue), Lee Schruben (Cornell), and Bill Biles (L.S.U.).

Attending non-members: G. Arthur Mihram, Michael Taaffe (Purdue), Barry Nelson (Purdue), Bill Kane (Northrop), Joe Shartiag (GTE), Mike Overstreet (Univ. of Alabama), Heimo Adelsberger (Univ. Veinna), Andy Gafarian (U.S.C.), and Marion Reynolds Jr. (Virginia Tech).

College Chairman, Bill Biles called the meeting to order.

1. Newsletter Editor, David Kelton, reminded the college to send him material for newsletter. Technical report abstracts, teaching aids, job announcements, news of promotions, changes of address, etc. were suggested. He also informed the college that the spring issue of the newsletter will come out after the 1984 Spring ORSA/TIMS national meeting so that it can contain ballots for the election of new college officers. A slate of nominations for college officers will be presented at the 1984 Spring ORSA/TIMS meeting in San Francisco.

2. Chairman, Bill Biles, reminded the college that there will be at least two candidates nominated for each office of the college except for that of chairman. The vice chairman will serve as the next chairman by divine right.

3. Treasurer, Lee Schruben, listed the expenses incurred since the last meeting. A formal treasurer's report will be submitted to the Spring 1984 newsletter.

4. **Management Science** Departmental Editor, George Fishman, reported that the department on simulation is well established with approximately twelve papers currently being processed.

5. W.S.C. college board representative, Alan Pritsker, reported that the 1983 conference is a success. Expenses are under budget and attendance is greater than planned for. The college should realize a substantial profit from our $2000 advance funding for the conference. Next year's Winter Simulation Conference will be held from November 28, 1984 to Novermber 30, 1984 in Dallas.

6. Chairman, Bill Biles, reported on the proposed TIMS College Service Award. During the meeting of the TIMS College on Simulation and Gaming at the 1982 San Diego Winter Simulation Conference it was proposed that the college consider awarding a plaque for outstanding service to the simulation community. A committee consisting of the College Chairman, W. Biles, Vice Chairman, Bruce Schmeiser, and Secretary-treasurer, Lee Schruben was asked to draft a proposal for such an award to be considered during the College meeting at the 1983 Winter Simulation Conference in Washington, D.C. Such a proposal was presented and discussed extensively. The award committee was asked to resubmit a proposal that included many of the concerns that were voiced during that discussion. This proposal will be presented for final college action at the 1984 San Fransisco ORSA/TIMS national meeting.

7. Robert Sargent suggested that the college award for the outstanding paper in **Management Science** be broadened to include any published paper. This suggestion received favorable discussion and will be a business item at the next college meeting in San Francisco.

8. Chairman Biles adjourned the meeting.

r. s.
Lee Schruben (Secretary)

MINUTES OF COLLEGE MEETING AT SAN FRANCISCO TIMS/ORSA CONFERENCE

Presiding: William Biles, Chairman

Attending: Herb Blake, Gordon Clark, Bruce Schmeiser, Lee Schruben, Jim Swain, Mike Taaffe, Arne Thesen, and Jim Wilson.

There was a college meeting at the San Fransisco joint TIMS/ORSA meeting on May 15, 1984. The meeting was called to order by the Chairman, William Biles. Professor Biles reported that the College has 255 active members. Professor Schmeiser reported on the College Service Award. Guidelines for that award are currently being finalized. Professor Biles reported that the nominating committee has selected a slate of candidates that will appear on a ballot in the Spring newsletter. The slate of candidates was approved by a voice vote.

Bruce Schmeiser proposed that the Statistical and Computing section of the American Statistical Association wishes to become a joint sponsor of the Winter Simulation Conference. After a lengthy discussion it was agreed by voice vote that the College would support this proposal.

respectfully submitted
Lee Schruben, Secretary

TREASURER'S REPORT

The College treasury increased slightly in 1983 and during the first part of 1984. Most of the income for the college comes from our annual sponsorship of the Winter Simulation Conference (W.S.C.). All members are encouraged to send suggestions to the newly elected College Chairman as to ways in which these funds can be put to productive use.

The 1983 Report to TIMS Headquarters contained the following revenues and disbursements.

REVENUES:

Interest (First Bank of Ithaca, NY)	$137.93
Dividends (Shearson)	300.70
1982 W. S. C. profit	2116.66
total	$2555.29

DISBURSEMENTS:

TIMS paper prize and plaques	$643.90
College sponsored mixers (two)	140.54
W. S. C. board of reps. expenses	366.00
total	$1150.44

The balance of our account at the First Bank of Ithaca, NY as of April 30, 1984 was $8090.74. We also have $2000 on advance to the 1984 W. S. C. In May we received a profit disbursement of $2807.17 from the 1983 Winter Simulation Conference. Our sponsorship of a mixer at the San Fransisco TIMS/ORSA meeting on May 15, 1984 cost $31.83.

r. s.
Lee Schruben
College Treas.

CONFERENCES

TIMS XXVI International Meeting, June 17-21, 1984, Copenhagen, Denmark.

Contact:
Julie Eldridge
TIMS
290 Westminster Street
Providence, Rhode Island 02903

1984 Summer Simulation Conference, July 23-25, 1984, Copley Plaza Hotel, Boston, Mass.

Contact:
Gert H. Wolfgang
Exxon Research and Engineering Company
P.O. Box 101
Florham Park
New Jersey 07932

IFORS '84, Tenth Triennial Conference on Operations Research, August 6-10, 1984, Washington Hilton Hotel, Washington, D. C.

Contact:
Richard M. Soland or Donald Gross
Department of Operations Research
School of Engineering and Applied Science
George Washington University
Washington, D. C. 20052

International 84 Minneapolis Summer Conference on Modeling and Simulation, organized by the Association for the Advancement of Modeling and Simulation Techniques in Enterprises (ASME), Minneapolis, Minnesota, August 13-17, 1984.

Contact:
AMSE
16 Avenue de Grange Blanche
69160 Tassin-la-Demi-Lune
France

Flexible Manufacturing Systems, August 15-17, 1984, Ann Arbor, Michigan.

Contact:
Kathryn Stecke
Graduate School of Business Administration
The University of Michigan
Ann Arbor, Michigan 48109

Computer Simulation-UKSC'84, September 12-14,1984 University of Bath, U. K.

Contact:
Murray Smith
Dept. of Electronics and Electrical Engineering
University of Glasgow
Glasgow, G12 8QQ, Scotland

ORSA/TIMS Joint National Meeting, November 26-28, 1984, Loews Anatole Hotel, Dallas, Texas.

Contact:
General Chairman U. Narayan Bhat
Dept. of Statistics
Southern Methodist University
Dallas, Texas 75275
(214) 692-2270
or Program Chairman Jeff Kennington
School of Engineering and Applied Science
Southern Methodist University
Dallas, Texas 75275
(214) 692-3099

1984 Winter Simulation Conference, November 28-30, 1984, Sheraton Dallas Hotel, Dallas, Texas.

Contact:
General Chairman Udo W. Pooch
Dept. of Computer Science
College of Engineering
Texas A&M University
College Station, Texas 77843
(409) 845-5498
or Program Chairman Dennis Pegden
Industrial Engineering Dept.
207 Hammond Bldg.
Penn. State University
University Park, Pennsylvania 16802
(814) 863-1675

Third Biennial Special Interest Meeting of Applied Probability Group of ORSA/TIMS on Statistical and Computational Problems in Probability Modeling, January 7-9, 1985, Fort Magruder Inn, Williamsburg, Virginia.

Contact:
General Chairman Carl M. Harris
Dept. of Systems Engineering
University of Virginia
Charlottesville, Virginia 22901
(804) 924-3803

SHORT COURSES

Editor's Note: We are pleased to include in the **Newsletter** announcements of short courses and seminars covering topics of potential interest to members of the College. Due to the number of such courses and the effort involved in assembling and writing these notices from advertising literature, we will in the future only publish notices that are sent to us, either from the instructors or the organizations offering the course, stating specifically that the notice is being submitted for consideration for publication in the **Newsletter.** The form should be as below: Title, dates and cities (at most five), description (100 words maximun), and whom to contact. The same deadline as for other **Newsletter** materials will apply.

Intensive 5-Day GPSS Courses

June 18-22, 1984, Ann Arbor, Michigan
October 15-19, 1984, Washington, D. C.
February 25-March 1, 1985, Washington, D. C.

GPSS is a well established, extremely popular computer language and run-time system used to build and perform simulations with discrete-event models of complex systems. Originating within IBM over 20 years ago, and having undergone major evolution since then, GPSS is available on both IBM and non-IBM hardware. IBM's current GPSS V, and the state-of-the-art GPSS/H, which is a superset of GPSS V, are studied in this course. The 5-day course blends (a) pre-course study, (b) transparency-based lectures, (c) written material, and (d) workshops using IBM Personal Computers and an Amdahl 5860 mainframe to impart to participants operational and sophisticated GPSS modeling skills.

Contact: Prof. Thomas J. Schriber, GSBA, University of Michigan, 48109, (313-764-1398).

Introduction to SIMAN

June 11-14, 1984, State College, Pennsylvania
September 1984, Boston, Massachusetts

A comprehensive course on simulation modeling using the SIMAN package. No prior knowledge of simulation is necessary.

Contact: Systems Modeling Corp., Calder Square P. O. Box 10074, State College, Pennsylvania 16805, (814)-238-5919.

Simulating Computer and Communications Networks with NETWORK II.5

June 19-22, 1984, Washington, D. C.

The course provides hands-on experience in simulating computer and communications systems through the use of NETWORK II.5. No prior simulation experience is required. A hands-on session utilizing the ideas introduced in the morning lecture is held every afternoon. Each student is provided with a copy of the course notes and the latest NETWORK II.5 documentation. The class makes use of NETWORK II.5, a design aid which takes a user-specified computer system description and provides measures of hardware utilization, software execution and conflicts. The instructor is Mr. William M. Garrison.

Contact: C. A. C. I., 12011 San Vicente Blvd., Los Angeles,California 90049, (213)-476-6511.

Simulation and Modelling with SIMSCRIPT II.5

June 11-15, 1984, Kansas City
July 16-20, 1984, Washington, D. C.
August 20-24, 1984, Los Angeles
September 17-21, 1984, Washington, D. C.

This course has been designed to introduce the concepts of simulation and model building in parallel with the introduction to the SIMCRIPT II.5 language. No prior simulation experience is required. Some familiarity with programming in a general purpose language (for example, FORTRAN, PL/1, or BASIC) is assumed. Starting from small "academic exercises," case studies are used to illustrate the power of SIMSCRIPT II.5 to model increasingly more complex situations. Most of the programming elements of SIMSCRIPT II.5 are covered as the model building proceeds. Student laboratory desk-exercises are used to reinforce the concepts introduced each day.

Contact: Dr. Ed Russell, CACI, Inc., 12011 San Vicente Blvd., Los Angeles, California 90049, (213)-476-6511.

Simulation Modeling and Analysis

June 19-22, 1984, San Diego
October 9-12, 1984, Washington, D. C.
November 6-9, 1984, San Francisco

Systems analysts, management scientists, and engineers interested in the efficient use of simulation techniques to analyze and/or optimize existing or proposed real-world systems will find this program of immediate value. All important aspects of simulation studies will be discussed. Simulation **Modeling and Analysis** by Law and Kelton will be the text for the program. The objective of this program is to provide each participant with the necessary background to model efficiently complex real-world systems, select the appropriate simulation language, decide which probability distributions to use as input, determine if the model is a valid representation of the system, analyze simulation output data, reduce the cost of obtaining the required statistical precision, and recognize problems which can cause conclusions to be invalid. The instructor is Dr. Averill M. Law, Professor of Management Information Systems, University of Arizona.

Contact: University Associates, P. O. Box 541, Princeton, New Jersey 08542, (609)-924-5656.

Simulation Modeling for Decision Making

June 25-27, 1984, San Francisco
July 18-20, 1984, Washington, D. C.
August 13-15, 1984, San Francisco
September 12-14, 1984, Washington, D. C.
October 15-17, 1984, San Francisco

This course will teach the basic concepts of digital simulation. The focus of the seminar is on the development and validation of simulation models and the use of those models in solving the complex and yet practical problems faced by every decision maker. The seminar is presented at a basic level and requires no prior experience in the analysis of systems through simulation. Each topic discussed will be accompanied by practical examples illustrating its application to the solution of real problems. At the beginning of the seminar, participants will receive a set of notes covering the topics of the seminar and including numerous illustrative examples. At the conclusion of the seminar, those attending will possess the knowledge necessary to develop simulation models to solve related decision problems. The instructor is Dr. J. William Schmidt, Professor of Industrial Engineering and Operations Research at Virginia Tech.

Contact: The Institute for Professional Education, 1515 North Courthouse Road, Suite 303, Arlington, Virginia 22201, (703)-527-8700.

SLAM II

July 17-20, 1984, West Lafayette, Indiana
September 18-21, 1984, Dallas, Texas
November 13-16, 1984, West Lafayette, Indiana

This comprehensive course will provide you with the information necessary to model complex systems from a variety of perspectives using SLAM II. It is intended for the problem solver who requires a flexible and effective simulation tool. Emphasis is on the approaches and procedures used to develop SLAM II simulation models. The course will provide you with a working knowledge of SLAM II approaches to simulation modeling and analysis, SLAM II symbols, simulation organizational structure, inputs and outputs, and SLAM II's practical applications in business, industry, and government.

Contract: Laura Stevens, Pritsker & Associates, P. O. Box 2413, West Lafayette, Indiana 47906, (317)-463-5557.

Statistical Techniques for Simulation Practitioners

July 30-August 3, 1984, West Lafayette, Indiana

The purpose of this seminar is to present methods to improve the analysis of simulation outputs. The course will present detailed information on graphical procedures for presenting statistical outputs, alternative statistical techniques, elementary regression analysis, experimental design, and quality control procedures as applied to simulation outputs. The use of these techniques for answering applied problems in a what-if framework will be demonstrated. This course is intended for individuals who have used simulation for problem solving and desire additional information on the use of statistical analysis techniques. Participants are presumed to know elementary statistics including the t-test and least squares. The emphasis will be on the interpretation of statistical techniques and their assumptions in a simulation context and not on the derivation of formulas. The instructors are Dr. Jack P. C. Kleijnen (principal instructor), Professor of Simulation and Information Management Systems, Katholieke Hoge-

school, Tilburg, Netherlands, Dr. Lee W. Schruben, Associate Professor of Operations Research and Industrial Engineering, Cornell University, and Dr. A. Alan B. Pritsker, President of Pritsker & Associates.

Contact: Pritsker & Associates, P. O. Box 2413, West Lafayette, Indiana 47906, (800)-428-7636.

ABSTRACTS OF PAPERS

ESTIMATING NETWORK RELIABILITY WITH ACCELERATED CONVERGENCE RATES ON ERROR BOUNDS, George S. Fishman, Tech. Report No. UNC-ORSA-TR-83/7, University of North Carolina, Chapel Hill, North Carolina 27514

Let G=(V,E) denote an undirected network with node set V and arc set E={1,...,N} . Arcs fail randomly and independently with probability $1-q_i$ for $\forall\ i \in E$. This paper describes a numerical procedure for estimating g(s,t), the probability that nodes s and t are connected for specified $s, t \in E$, with bounds on absolute error proportional to 1/K for a specified nonrandom finite sequence and proportional to log K/K for certain nonrandom infinite sequences, where K is the number of replications. These convergence rates are best possible. Although the infinite sequences have a slower convergence rate than the finite sequence has, they offer the convenience of allowing one to add replications and retain the rate whereas the finite sequence does not. These bounds improve on the convergence rate $O(1/K^{1/2})$ for the standard error in the case of independent Monte Carlo replications based on random sampling. Moreover, they hold with certainty. Algorithms for computing estimates are shown to have an upper bound $O(N)+O(\max(N, |V|))$ on time complexity per replication as $K \to \infty$.

The paper first describes the estimation of g(s,t) for $q_1 = \ldots = q_N = p$ by using a tabled truncated binomial distribution together with the A-canonical representation of a positive integer. It then describes how to incorporate stratified sampling to estimate g(s,t) as a function of p at small marginal increase in time complexity. Next, the paper extends the stratified sampling method to the case of unequal $q_1, \ldots, q_N$.

An example based on a network of 30 arcs illustrates the techniques. Lastly, the paper extends the method to the estimation of g(s,t), the probability that s and t are connected for all $t \in T \subseteq E-\{s\}$.

ESTIMATING TIME AVERAGES VIA RANDOMLY-SPACED OBSERVATIONS, Bennett L. Fox and Peter W. Glynn, MRC Technical Summary Report # 2638, Mathematics Research Center, University of Wisconsin-Madison, 610 Walnut Street, Madison, Wisconsin 53705

To estimate continuous-time averages via randomly-spaced obserations of discrete-event systems, we develop a point-process framework and use it to generalize both regenerative and stationary-process oriented simulation methodologies. We give consistent estimators, central limit theorems, and an effective bias-reducing jackknife. The impact on indirect estimation of transaction (customer) averages is discussed.

ON ARMA REPRESENTATIONS FOR WHITE NOISE IN A MARKOVIAN ENVIRONMENT, Peter W. Glynn, MRC Technical Summary Report # 2588, Mathematics Research Center, University of Wisconsin-Madison, 610 Walnut Street, Madison, Wisconsin 53705

Consider an environment having d possible states, where the state of the environment evolves through time according to a stationary Markov chain. A natural model for noise in such an environment is to assume that the disturbance is driven by a white noise process that depends on the current state of the environment. In this note, it is shown that such a noise process may be represented by a (d+1)th order ARMA model.

SOME ASYMPTOTIC FORMULAS FOR MARKOV CHAINS WITH APPLICATIONS TO SIMULATION, Peter W. Glynn, MRC Technical Summary Report #2487, Mathematics Research Center, University of Wisconsin-Madison, 610 Walnut Street, Madison, Wisconsin 53706

Formulas are derived for the initial bias, variance, and spectrum of the sample mean in finite state Markov processes. The focus is on application of such expressions to the steady-state simulation problem.

RANDOMIZED ESTIMATORS FOR TIME INTEGRALS, Peter W. Glynn,, MRC Technical Summary Report #2603, Mathematics Research Center, University of Wisconsin-Madison, 610 Walnut Street, Madison, Wisconsin 53705

Let $\{X(t) : t \geq 0\}$ be a real-valued stochastic process and set $\alpha = \int_0^\infty X(t)\, G(dt)$, where G is a (non-random) distribution function. If the support of G is large, standard Monte Carlo techniques for estimating α are inefficient, since X must be simulated over the entire support of G. To avoid this difficulty, randomization schemes are derived that require simulation of X over random subsets of the support of G. Large-sample behavior of randomized estimators is studied in detail. Some variance reduction techniques are also presented.

EVALUATION AND COMPARISON OF CONFIDENCE INTERVAL PROCEDURES, Keebom Kang and Bruce W. Schmeiser, Research Memorandum No. 83-3, School of Industrial Engineering, Purdue University, West Lafayette, Indiana 47907

Coverage contours and scatter diagrams, which can be used as tools for evaluating and comparing confidence interval estimation procedures, are developed. The contours combine both the ideas of the power function and the coverage function; both the expected width and the probability of coverage appear in one figure. The scatter diagrams are used for graphical representation of the expected width and variance of the interval, and of the asymmetry of the coverage.

TRANSIENT EXPONENTIAL-ERLANG QUEUES AND STEADY-STATE SIMULATION, W. David Kelton, Technical Report No. 84-7, Department of Industrial and Operations Engineering, The University of Michigan, Ann Arbor, Michigan 48109

The transient probabilistic structure of arbitrarily initialized $M/E_m/1$ and $E_m/M/1$ queues is derived in discrete time. Computational algorithms for obtaining the required probabilities are provided, and their application in calculating a variety of system performance measures is illustrated. The results are used to investigate the question of initializing simulations of systems such as these in order to promote rapid convergence to steady state, if that is the object of the simulation. These results are consistent with earlier studies for transient queueing systems, such as the M/M/s, but allow greater flexibility in specification of interarrival or service-time models inherent in the Erlang distributions.

A SIMULATION MODEL FOR PUBLIC POLICY ANALYSIS, Rueben R. McDaniel, Robert S. Sullivan, James R. Wilson, Mechanical Engineering Department, The University of Texas, Austin, Texas 78712

This paper describes a new approach to large-scale simulation modeling for policy analysis in the public sector. Whereas conventional microanalytic simulation models extrapolate the detailed behavior of a representative sample of individuals to the corresponding target population, the new modeling technique disaggregates an exogenous demographic forecast into enough detail to evaluate the impact and cost of proposed social programs. This approach uses a multivariate extension of Johnson's univariate translation systems in order to estimate the percentage of individuals in a target population who satisfy alternative program eligibility criteria. The methodology in demonstrated in a prototype decision support system for analysis of the Institutional Care and Community Care programs of the Texas Department of Human Resources. The new approach appears to be more technically and politically acceptable than conventional microanalytic simulation modeling, and consequently it could have broad applications for enhancing public policy decisions.

VARIANCE REDUCTION IN SIMULATION EXPERIMENTS: A MATHEMATICAL-STATISTICAL FRAMEWORK, Barry L. Nelson, School of Industrial Engineering, Purdue University, West Lafayette, Indiana 47907

With the expanding use of computer simulation to model and solve industrial engineering problems, there has been increasing interest in the development of efficient simulation techniques. When the concern is for statistical efficiency of results that are random variables, such approaches are usually called variance reduction techniques (VRTs).

Many of the fundamental ideas in simulation, and particularly techniques for efficient simulation, had their origins in the Monte Carlo estimation literature. The theory of sampling is another closely related field that predates the development of simulation. Although there has been significant research interest in variance reduction, there have been few attempts to structure and define the discipline.

VRTs are transformations. They transform simulation experiments into related experiments that yield better estimates of some parameters of interest, where better usually means more precise. This research identifies and defines the components from which all variance reduction techniques are built. Given a general mathematical-statistical definition of simulation experiments, these components or classes of transformations are shown to be useful, to be mutually exclusive, and to generate all possible VRTs via composition. Benefits of the research include: 1) the facility to unambiguously define new or existing VRTs, eliminating confusion that currently exists in the literature, 2) the facility to decompose VRTs into combinations of transformations, making the relationships between VRTs clear, 3) the development of a theoretical foundation for analytical treatment of VRTs, and 4) the development of a setting for proposing new VRTs and research questions. In addition, increased understanding of the area should promote more and better application of variance reduction in practice.

CONTROL VARIATES IN THE METHOD OF AUTOREGRESSION, Ardavan Nozari and Varkey P. Alapat, School of Industrial Engineering, University of Oklahoma, Norman, Oklahoma 73019.

A methodology is developed for the use of control variates in the application of autoregressive processes to steady state simulation. The methodology is tested with an M/M/1 queue and a system of tandem queues. The empirical results indicate that employing control variate can substantially increase the accuracy of confidence intervals.

AN ARMA-BASED CONFIDENCE-INTERVAL PROCEDURE FOR THE ANALYSIS OF SIMULATION OUTPUT, Thomas J. Schriber, Richard W. Andrews, Working Paper No. 304, Graduate School of Business Administration, The University of Michigan, Ann Arbor, Michigan 48109

A methodology is presented for building an interval estimate on the mean of a stationary stochastic process. The method fits an autoregressive moving average (ARMA) model to a sequence of a sample outputs from the process. If the model is statistically acceptable, it is used to estimate the variance of the sample mean and the applicable degrees of freedom of the t statistic, from which a confidence interval is then produced. Each of the steps involved, including fitting and testing the ARMA model, has been totally automated. The effectiveness of the confidence-interval procedure has been measured by examining the characteristics of 2,400 confidence intervals resulting from applying the procedure to simulation output sequences generated by six ARMA models. Five measures of effectiveness are used. Performance characteristics of the procedure are good to excellent for output sequences consisting of 100 or 200 observations, and are excellent for output sequences consisting of 300 or 400 observations.

BATCH RATIOS IN DISCRETE EVENT SIMULATION, Andrew F. Seila, Department of Management Science, The University of Georgia, Athens, George 30602

The use of fixed-length batches is a convenient way to collect data and synchronize batches when estimating multiple parameters. This paper discusses the use of batch ratios computed from fixed-length batches to estimate the mean of a stationary

output process. Batch ratios are shown to have the same asymptotic properties as batch means. Implementation considerations are also discussed.

MULTIVARIATE ESTIMATION OF CONDITIONAL PERFORMANCE MEASURES IN REGENERATIVE SIMULATION, Andrew F. Seila, Department of Management Science, The University of Georgia, Athens, Georgia 30602

Conditional performance measures are defined and a multivariate estimator for a vector of conditional performance measures in regenerative simulations is presented and shown to be asymptotically normal. Methods for computing approximate large sample joint and simultaneous confidence intervals are discussed. Empirical studies show that this methodology permits reliable simultaneous confidence intervals to be computed using sample of moderate size; however, very large sample sizes are required for valid confidence regions.

MULTIVARIATE OUTPUT ANALYSIS IN DISCRETE EVENT SIMULATION: THE STATE OF THE ART, Andrew F. Seila, 84-151, Department of Management Science, The University of Georgia, Athens, Georgia 30602

Inferential procedures are discussed for estimating multiple stationary mean parameters in simulations with multivariate output processes. These techniques include classical procedures applicable to i. i. d. observations, procedures for regenerative processes, multivariate batch means and a new batch ratio method. Conditions underwhich each method can be applied are also discussed as well as implementation considerations.

SIMTOOLS: A SOFTWARE TOOL KIT FOR DISCRETE EVENT SIMULATION IN PASCAL, Andrew F. Seila, Department of Management Science, The University of Georgia, Athens, Georgia 30602

We show how discrete event simulation programs can be developed and coded in Pascal using a kit of software tools. The particular tool kit used, SIMTOOLS, which implements the event view, consists of simple data structures and routines, which facilitate entity creation and deletion, list processing, and event scheduling and sequencing. Our purpose is to suggest that in many model-building efforts which do not fall neatly into the class of queueing networks, it might be easier and more efficient to develop and use a software tool kit, such as SIMTOOLS. The advantages of such an approach include the ability to apply top-down design and structured programming techniques, self-documentation, portability and the fact that a Pascal compiler is the only development software required.

OPTIMAL UNIVARIATE ROTATION SAMPLING, James R. Wilson, Department of Mechanical Engineering, University of Texas, Austin, Texas 78712

As a special case of the antithetic-variates technique, univariate rotation sampling generates correlated replicates of a Monte Carlo response function using translations modulo 1 of the random number input by a fixed set of "angles." The response function is assumed to be monotone with finite variance. This paper establishes the following property: with respect to the angle of rotation between two inputs, the covariance between the corresponding outputs is a convex function. This result is used to show the optimality of a class of rotation sampling schemes with regularly spaced angles of rotation.

STATISTICAL ASPECTS OF SIMULATION, James R. Wilson, Mechanical Engineering Department, University of Texas, Austin, Texas 78712

This paper surveys state-of-the-art developments in the design and analysis of simulation experiments. The following topics are discussed: (1) transient and steady-state output analysis techniques, (2) methods for handling initialization bias, (3) ranking and selection procedures, and (4) variance reduction techniques.

VARIANCE REDUCTION TECHNIQUES FOR DIGITAL SIMULATION, James R. Wilson, University of Texas, Austin, Texas 78712

In the design and analysis of large-scale simulation experiments, it is generally difficult to estimate model performance parameters with adequate precision at an acceptable sampling cost. This paper provides a state-of-the-art survey of the principal variance reduction techniques that have been developed to improve the efficiency of simulation-based performance statistics.

VARIANCE REDUCTION TECHNIQUES IN STOCHASTIC SIMULATION, James R. Wilson, Department of Mechanical Engineering, University of Texas, Austin, Texas 78712

From both a theoretical and practical standpoint, experimentation with a Monte Carlo simulation model is frequently the only feasible means for performing systems analysis on large-scale problems. However, the computing cost associated with direct simulation of complex stochastic systems can be a major drawback. In particular, excessive sample sizes may be required to yield acceptable precision in simulation based estimators of relevant system parameters. This article surveys the principal variance reduction techniques that have been developed to improve the efficiency of such estimators.

SIMULATION EDUCATION: SOFTWARE–AUGMENTED TEXTBOOKS EMPHASIZING MODELLING CONCEPTS, Bernard P. Zeigler, Tuncer I. Oren, CSC-83-008, Wayne State University, Detroit, Michigan 48202

This paper advances the proposition that new approaches to the teaching of modelling and simulation are needed if this conceptual and practical tool is to reach its full potential in the information society of tomorrow. The new approach that we advocate co-ordinates textbook material that is based on methodological concepts (rather than a traditional simulation language)

with a microcomputer software package that acts as the medium for exercising the concepts in the context of various modelling formalisms.

We summarize the features of the methodologically based approach in the following points:

*) based on methodologically sound concepts rather than a particular language
*) teaches a number of basic simulation modelling formalisms in a conceptually unified manner
*) employs the latest computer technology available to augment traditional lecture and self study
*) prepares students for the openness of approach necessary for coping with the information society to which they will belong

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