THE INSTITUTE OF MANAGEMENT SCIENCES

NEWSLETTER OF THE
TIMS COLLEGE on SIMULATION AND GAMING

LEE SCHRUBEN and W. DAVID KELTON, CO-EDITORS

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

FIRST CLASS

MEETINGS

Sessions at Houston ORSA/TIMS Meeting

The College sponsored six sessions at the ORSA/TIMS meeting in Houston, October 11-14, 1981. Eighteen papers dealt with new developments in simulation, including statistical techniques, new language developments, simulation of manufacturing and material handling systems, and state-of-the-art surveys. The sessions were:

New Developments in Simulation Languages (MA12)
State-of-the-Art Surveys of Simulation Methodologies (MB12)
Simulation of Manufacturing Systems (MC12)
Simulation of Large Scale Material Handling Systems (MD12)
Statistical Techniques in Computer Simulation I (WA12)
Statistical Techniques in Computer Simulation II (WB12)

Some other sessions which could be of interest to members of the College were:

Operations Research Applications in Renewable Energy Souuces (TA08)
Statistics and Optimization -- The Interface (TA17)
Queuing Software (TB10)
Stochastic Combat Models (TB13)
Control of Queuing Processes (TC13)
Computational Aspects of Applied Probability (TD10)

There was also a business meeting of the College on Tuesday, October 13, at 5:30 in the "Dogwood B" room.

1981 Winter Simulation Conference

The 1981 Winter Simulation Conference will be held in Atlanta, December 9-11, in the Peachtree Plaza Hotel. The General Chairman is:

Claude M. Delfosse
CACI, Inc.
1815 North Fort Myer Drive
Arlington, Virginia 22209
(703) 841-7800

The registration Chairman is:

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

To obtain a reduced rate, register before November 1.

RECENTLY PUBLISHED BOOKS

New Simulation Textbooks

John Wiley & Sons have announced the publication of the book, *Simulation and the Monte Carlo Method,* by Reuven Y. Rubinstein of the Technion in Israel as part of the Wiley Series in Probability and Mathematical Statistics. The new text, *Simulation Modeling and Analysis,* by Averill M. Law of the University of Arizona and W. David Kelton of Kent State has also recently been published (McGraw-Hill Book Company). Both of these fine books appear to be well received by the simulation community.

Members of the college who know of other significant additions to the simulation literature are encouraged to inform the Newsletter editors.

New Addresses

Averill Law, current TIMS college president, has accepted a permanent position on the faculty of the Department of Management Information Systems, College of Business and Public Administration, University of Arizona, Tucson (Zip 85721), phone (602) 626-3116).

Robert Sargent is a visiting faculty member for 1981-82 at the School of OR&IE, Engineering College, Cornell University, Ithaca, NY (Zip 14853, phone (607) 256-4856).

Bill Biles has become Chairman of the Industrial Engineering Department at Louisiana State University. His new address is:

3128 CEBA
Louisiana State University
Baton Rouge, Louisiana 70803
(504) 388-5112

Steve Lavenberg of the IBM Thomas J. Watson Research Lab is on leave visiting the Department of Computer Science/Bolter Hall/UCLA, Los Angeles, CA 90024.

Surely other college members have new visiting or permanent positions with Universities or Industrial Organizations; please let us know by sending a brief note to the Newsletter editors.

Management Science AWARD

Lee W. Schruben, School of Operations Research and Industrial Engineering, Cornell University, has won the first annual "Best Paper in Simulation and Gaming" award for "A Coverage Function for Interval Estimators of Simulation Response," *Management Science,* 26, 1 (January 1980), 18-27. The award consists of $500 and a plaque, which was presented at the Award Luncheon on October 13, 1981 at the Houston ORSA/TIMS Meeting.

Six papers were nominated. Award selection was by vote of the members of TIMS College on Simulation and Gaming (everyone receiving this newsletter). I thank all the members of the college who took the time to vote this year.

Bruce Schmeiser, Award Chairman

Teaching Aids

Professor William Maxwell at Cornell has used a technique for several years to illustrate how simulation models can become unreasonably detailed. He brings a large illustrated children's book called "The House that Jack Built" to class and simply reads it *backwards*. Take a look at this classic children's story. It makes a good show and really hits home.

News

A few regular contributors have sent us material for the College newsletter. . .how about the rest of our 250 members?

Some suggestions

(1) Abstracts of research reports or papers
(2) Announcements of seminars or short courses
(3) Questions for homework or exams for teachers
(4) Problems for some of our member consultants
(5) Job openings

We would love to have a large work load (Eds.)

ABSTRACTS OF PAPERS

LINEAR COMBINATIONS OF INDIRECT ESTIMATORS FOR VARIANCE REDUCTION IN REGENERATIVE SIMULATIONS, John S. Carson II, Georgia Institute of Technology.

Abstract: We investigate using linear combinations of the standard estimator and indirect estimators as a variance reduction technique in the simulation of regenerative queuing models. Indirect estimators are estimators suggested by conservation equations or other simple relations such as Wald's equation. We establish the asymptotic validity of these confidence intervals when the optimum weights are estimated from the data, andempirically investigate the finite sample properties of the resulting estimator. In particular, for several estimation schemes, we study probability coverage, variance of the point estimator, and confidence interval width. Based on experiments and theoretical calculations with the M/G/1 queue, plus experiments with two models of closed queuing networks, we conclude that two newly proposed schemes which estimate the optimum weights for the variance estimator from a fraction of the data, but use all the data for the point estimator, provide better finite sample properties than previously proposed methods.

ANALYSIS OF SIMULATION EVENT INCIDENCE GRAPHS, Lee Schruben, School of OR&IE, Cornell Univ., Ithaca, NY 14850 Tech. Rpt. No. 498.

Abstract: The event incidence graph presented here can be used to develop alternative event oriented representation of a system. Several candidate model structures can be considered for possible implementation as discrete event simulation programs using an event-scheduling approach. Applications of basic graph analysis techniques are illustrated in the context of a simple example.

MODEL REPRESENTATION IN DISCRETE EVENT SIMULATION: THE CONICAL METHODOLOGY*, Richard E. Nance, Dept. of Computer Sicence, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.

Abstract: Beginning with a brief review and classification of model development approaches, we characterize the simulation model life cycle as comprised of seven phases: the conceptual model, the communicative model, the programmed model, the experimental model, model results, use of the model for integrated decision support, and the modification and extension of the model. This characterization places severe requirements on the task of model management (creation, acceptance, use, revision or extension, and reuse). The Conical Methodology has been developed in response to the needs that predominate the model development phases (from conceptual model to model results). Definitions used in the Conical Methodology are explained, and the approach is illustrated with a machine repairman example. An incomplete critique of the result and the approach concludes the paper.

A NEW APPROACH FOR DEALING WITH THE STARTUP PROBLEM IN DISCRETE EVENT SIMULATION, W. David Kelton and Averill M. Law, Technical Report WS-8103, Department of Administrative Sciences, Kent State Univ.

Abstract: This paper proposes a practical, data-based statistical procedure which can be used to reduce or remove bias owing to artificial startup conditions in simulations aimed at estimating steady-state means. We discuss results of experiments designed to choose good parameter values for this procedure, and present results of extensive testing of the procedure on a variety of stochastic models for which partial analytical results are available. The paper closes with two illustrations of the application of the procedure to more complex statistical problems which are more representative of the kinds of purposes for which real-world steady-state simulation studies might be undertaken.

VARIANCE REDUCTION AND THE JOINT ESTIMATION OF TWO MEAN MEASURES OF PERFORMANCE OF QUEUEING SYSTEMS, John Carson, School of ISyE, Georgia Tech., Atlanta, Georgia. (no abstract)

SENSITIVITY ANALYSIS OF DISCRETE EVENT SIMULATIONS: A FREQUENCY DOMAIN APPROACH, Lee W. Schruben and Vincent James Cogliano, School of OR&IE, Cornell Univ., Ithaca, NY 14853-0371, Tech. Rpt. No. 514.

Abstract: A technique is presented for assessing the sensitivity of a discrete event digital simulation model to the values assumed for continuous input parameters. A frequency domain approach is taken where input parameters oscillate throughout a simulation run. Parameter sensitivity is indicated by changes in the frequency spectrum of the output process. A distinct frequency band is assigned to each of the parameters; the experimental units are frequency bands rather than runs of the simulation program. For each run a large number of frequency bands are available with nearly independent spectrum estimators. Therefore, frequency domain experiments can be less expensive than traditional (run-oriented) simulation experiments. The significance of terms in a regression model for the simulation response surface is measured. This information can be used to design experiments for more detailed analysis and to screen unimportant parameters from further study.

THE PROBLEM OF EXPERIMENTAL DESIGN IN SIMULATION, Dennis E. Smith and Carl A. Mauro, Desmatics, Inc., Applied Research in Statistics - Mathematics - Operations Research, P.O. Box 618, State College, PA 16801, Tech. Rpt. No. 113-4.

Abstract: In many cases, a simulation study may be viewed as an experimental situation in which a number of factors (independent variables) are to be investigated. However, standard experimental design techniques often require more simulation runs than are available to the simulation user. In general, the primary problem of experimental design in simulation can be succinctly summarized as too many factors and too few runs. A discussion of this problem is presented in this report. Three possible two-stage strategies for attacking the problem are considered, and performance measures with which to judge the strategies are described.

REGENERATIVE SIMULATION OF NETWORKS OF QUEUES WITH GENERAL SERVICE TIMES: PASSAGE THROUGH SUBNETWORKS, Gerald S. Shedler and Jonathan Southard, IBM Research Laboratory, San Jose, CA 95193.

Abstract: A linear "job stack", an enumeration by service center and job class of all the jobs, is an appropriate state vector for simulation of closed, multiclass networks of queues with priorities among job classes. Representation of the job stack process as an irreducible generalized semi-Markov process leads to an estimation procedure for passage times in networks with general service times. The method provides point estimates and confidence intervals from a single simulation run.

SIMULATION FOR PASSAGE TIMES IN CLOSED, MULTICLASS NETWORKS OF QUEUES WITH UNRESTRICTED PRIORITIES, Gerald S. Shedler and Jonathan Southard, IBM Research Laboratory, San Jose, CA 95193.

Abstract: Regenerative simulation for passage times in multiclass networks of queues with priorities can be based on observation of a fully augmented job stack process which maintains the position of each of the jobs in a linear "job stack", an enumeration of the jobs by service center and job class. Iglehart and Shedler have shown that point estimates and confidence intervals for general characteristics of passage times can be obtained from a single simulation of an irreducible fully augmented job stack process. The primary effect of the irreducibility assumption is to restrict the priority structures and network topologies that can be handled. In this paper we extend the applicabiltiy of the estimation method by removing essentially all of these restrictions.

SIMULATION FOR PASSAGE TIMES IN CLOSED, MULTICLASS NETWORKS OF QUEUES WITH GENERAL SERVICE TIMES, Donald L. Iglehart, Dept. of Operations Research, Stanford Univ., Stanford, CA 94305 and Gerald S. Shedler, IBM Research Laboratory, San Jose, CA 95193.

Abstracts: An appropriate state vector for simulation of closed, multiclass networks of queues with priorities among job classes is a linear "job stack", an enumeration by service center and job class of all the jobs. Simulation for passage times can be based on observation of an augmented job stack process which maintains the position of an arbitrarily chosen "marked job". Using a representation of the augmented job stack process as a generalized semi-Markov process, we develop an estimation procedure for passage times in networks with general service times. Based on a single simulation run, the procedure provides point estimates and confidence intervals for general characteristics of passage times.

PROPERIES OF BATCH MEANS FROM STATIONARY ARMA (1,1) TIME SERIES, Bruce Schmeiser and Keebom Kang, School of Industrial Engineering, Purdue Univ., West Lafayette, IN 47907, Research Memorandum No. 81-3.

Abstract: For stationary first order autoregressive and autoregressive moving average processes with normally distributed erros, the corresponding stationary process of batch means is shown to be an autoregressive moving average process. The batch means process resulting from a moving average process, however, is shown to be a moving average process. The parameters of the batch means process are closed form functions of the batch size and parameters of the original process.

A COMPLETE GUIDE TO GAMMA VARIATE GENERATION, Pandu R. Tadikamalla, Univ. of Pittsburgh, Pittsburgh, PA 15260 and Mark E. Johnson, Los Alamos National Laboratory, Los Alamos, NM 87545, *American Journal of Mathematical and Management Sciences*, 1981, Vol. 1,3 (in press).

Abstract: Considerable attention has recently been directed at developing simpler and faster algorithms for generating gamma random variates (with general, not necessarily integral, shape parameter α) on digital computers. This paper surveys the current state of the art, which inlcudes fifteen gamma algorithms applicable for $\alpha \geq 1$ and six that are applicable for $\alpha < 1$. These algoritms are compared according to the criteria of speed and simplicity. General random variate generation techniques are explained with reference to these gamma algorithms. Computer simulation experiments on DEC and CDC computers are reported. Guidelines for some specific applications are given.