CONTENTS

CHAIRMAN'S COLUMN .................................................. 1
RECEPTION AT THE ORSA/TIMS MEETING IN
WASHINGTON, D. C. .................................................... 2
AN OFFER: TECHNIQUES ON EFFICIENT
MONTE CARLO SIMULATION .............................................. 2
CALL FOR PAPERS .......................................................... 2
STANDARDIZATION OF SIMULATION LANGUAGES ............... 2-3
ABSTRACTS OF RECENT PAPERS ..................................... 3-6
BIBLIOGRAPHY ON FUTURE EVENT SET
ALGORITHMS ............................................................... 7-9
BIBLIOGRAPHY ON RESEARCH AND DEVELOPMENT
SYSTEM DYNAMICS ...................................................... 10
BIBLIOGRAPHY ON VALIDATION OF SIMULATION
MODELS ................................................................. 11-15
CHAIRMAN'S COLUMN

This issue of the Newsletter has a change in one of its two editors. Professor Averill Law, who is one of the two co-founding editors, has retired. I thank Averill on behalf of the College for his services. Professor Lee Schruben is the new Co-editor, and he and the continuing Co-founding Editor, Professor Bruce Schmeiser, will now be producing the Newsletter.

As announced in the last Newsletter, the College will publish bibliographies, so please prepare and forward bibliographies in your area of specialization for the College to publish and distribute. There are three bibliographies on specific topics in Simulation contained within this issue of the Newsletter.

The College has been and continues to be busy with conferences and meetings. We are a co-sponsor of the Winter Simulation Conference. The 1979 Conference, held in San Diego, was successful, and the 1980 Conference will be held December 3-5 in Orlando, Florida. At the ORSA/TIMS meetings in Milwaukee in October, a Social Mixer was held, and due to its success, another Mixer is going to be held at the ORSA/TIMS Meeting in Washington, D.C., in May. Please see the announcements at the meeting for the time and place.

A business meeting of the College will take place Monday evening, May 5, at 6:00 p.m. at the National ORSA/TIMS Meeting in Washington, D.C. I hope you will be able to attend; the meeting held at the 1979 Winter Simulation Conference was excellent.

As noted in the last Newsletter, Management Science now has a Department of Simulation for which Professor George S. Fishman is editor. This is an excellent place to publish your simulation papers.

I urge each of you to become involved with our College in some way, and if you have any ideas for the College, please contact any of its offices. Our strength is dependent upon you, the members.

Robert G. Sargent  
Department of Industrial Engr.  
& Operations Research  
Syracuse University  
Syracuse, NY 13210
RECEPTION AT THE TIMS/ORSA MEETING IN WASHINGTON, D. C.

You should have all received your bulletins, so you know there are many sessions on simulation, as usual. What you may not know, because it is not in the bulletin, is the we are planning the second semiannual reception of the TIMS College on Simulation and Gaming. It will be Tuesday, May 6, from about 8 P.M. to about 11 P.M. The location is still up in the air, but it will be announced at each of the TIMS College on Simulation and Gaming sessions, as well as on the message board.

The reception in Milwaukee went well, despite lack of publicity. It was not fancy, being held in my room (BWS) and with Averill Law carrying in the refreshments (Thanks). About 40 people attended and it seemed to me that most everyone had a good time and had a chance to meet others with similar (get it?) interests.

AN OFFER: TECHNIQUES OF EFFICIENT MONTE CARLO SIMULATION

Professor Richard E. Beckwith has a number of three-volume sets of TECHNIQUES FOR EFFICIENT MONTE CARLO SIMULATION by McGrath, et al. He is willing to distribute the excess copies on a First-Come First-Serve basis. Dick’s address is

Professor Richard E. Beckwith
Graduate School of Business Administration
Tulane University
New Orleans, LA 70118

These volumes seem to be little known, but are quite good (opinion, BWS). The first volume is on selection of probability distributions, the second is on random number generation, and the third is on variance reduction techniques. These were done about 1973-4 with support of the Office of Naval Research.

CALL FOR PAPERS

Lee Schruben has begun serving as an associate editor for SIMULATION. His area is discrete models and methodology. SIMULATION is a fully referred journal. Anyone wishing to have a general interest paper on discrete simulation considered for publication should send four copies to

Natalie Fowler, Managing Editor
Attn: Lee Schruben
SIMULATION
P.O. Box 2228
La Jolla, CA 92038

STANDARDIZATION OF SIMULATION LANGUAGES

On September 20-21, 1979, the Sorrento Workshop for the International Standardization of Simulation Languages was held in St. Agata, Italy. Attendance at the workshop was by invitation only, and the group included a mix of persons working in the areas of discrete event and continuous simulation. After introduction and an opening statement by the workshop organizers, several attendees presented position papers developed for the workshop. The issues surfacing during the presentation ranged from very general (at what level should standardization even be contemplated) to rather specific (improvements to the CSSL specification developed by IMACS several years ago).
Following the presentation of position papers, discussion evolved around some major points:

1. What is a language? What is a model? Should there be a base language?
2. Should there be a combined modeling language?
3. Is the user community identifiable?
4. Where do problem oriented languages fit in?
5. Do current hardware developments have any implications for simulation model or base model languages?

Following extended discussion, several issues were identified and through a vote of the attendees, some consensus was reached regarding the importance of the various issues. The decision was made to establish an ongoing effort through two task forces and an executive committee. Elected as Chairman of that Executive Committee was Maurice S. Elzas (The Netherlands), Vice Chairman, Richard E. Nance (U.S.A.), Secretary, Francois Cellier (Switzerland).

Subcommittee Chairman also elected were:
1. Vocabulary development: Professor Tuncer Ören (Canada)
2. Simulation and Modeling Formalisms: Professor Bernard Zeigler (Israel)

**ABSTRACTS OF RECENT PAPERS**

The response to our publishing abstracts of recent work has been quite favorable, both in terms of comments and the number of people submitting abstracts. The current batch is characterized by an increase in thesis abstracts.

We encourage especially abstracts from these and technical reports, since these are often of interest (being timely) but also the hardest to be aware of. Of course, recently published papers are also welcome.

The address for abstracts is:

Dr. Lee Schruben
School of Operations Research and
Industrial Engineering
Cornell University
Ithaca, NY 14853

---

*The Application of Regression Methods to the Initial Transient Problem in Computer Simulation*, Mark K. Snell
Ph D. Dissertation, School of Operations Research and Industrial Engineering, Cornell University 14853.

Using general families of growth models in regression, transient data can be included in estimators characterizing long-term behavior of simulations. These estimators offer an alternative to output truncation and can be used when runs are short relative to initial transient periods.

*Small-Sample Behavior of Weighted Least Squares in Experimental Design Applications*, Jack Kleijnen, Renee Brent, Rien Brouwers, Department of Business and Economics, Tilburg University (Katholieke Hogeschool Tilburg) Tilburg, Netherlands.

In experimental design applications unbiased estimators $\hat{\sigma}_1^2$ of the variances $\sigma_1^2$ are possible. These estimators may be used in Weighted Least Squares (WLS) when estimating the parameters $\theta$. The resulting small-sample behavior is investigated in a Monte Carlo experiment. This experiment shows that an asymptotically valid covariance formula can be used if $\hat{\sigma}_1^2$ is based on, say, at least 5 observations. The WLS estimator based on estimators $\hat{\sigma}_1^2$ gives more accurate estimators of $\theta$, provided the $\sigma_1^2$ differ by a factor, say, 10.

*Validation of Simulation Models*, Robert G. Sargent, Department of Industrial Engineering and Operations Research Syracuse University, Syracuse, New York 13210.

This is a tutorial paper on validation of simulation models. Included in this tutorial are what is meant by validation, the problem dependent characteristics of simulation model validation, descriptions of the various validation techniques and their use and a discussion on the statistics used in validation techniques (but not the detailed statistical tests themselves).


In running simulation experiments there is often concern whether or not the starting conditions have caused a serious bias in the results. A procedure is presented for testing the significance of initialization bias in simulation output. The test is based on easily computed statistics and should offer guidance for simulation initialization in a variety of situations.
Estimation of the Sum of Differences Distribution, Stuart Jay Deutsch, Georgia Institute of Technology, Atlanta, Georgia 30332; Bruce Wayne Schmeiser, Purdue University, West Lafayette, Indiana 47907.

Consider the distribution of \( \sum_{i=1}^{n} d_i \), where the \( d_i \)'s are differences independently, identically and symmetrically distributed with mean zero. The problem is to determine properties of the sdd given the distribution of the \( d_i \)'s and the sample size \( n \). The standardized moments as a function of the moments of the \( d_i \)'s are developed. A variance reduction technique for estimating the quantiles of the sdd using Monte Carlo methods is developed based on using the randomization sample consisting of the \( n \) values of \( \sum_{i=1}^{n} d_i \) rather than the single observation \( \sum_{i=1}^{n} d_i \) corresponding to each sample \( d_1, d_2, \ldots, d_n \). The randomization sample is shown to produce unbiased and consistent estimates of the moments and biased and consistent estimates for the quantiles of the sdd. For small sample sizes, variance reduction of up to 99.7% is achieved.


This paper is a tutorial paper on how to obtain point and interval estimates (confidence intervals) of means for both terminal and steady state simulations. The simple methods of replication, batch means, and regenerative cycles are presented in detail and applied to a model of a simple time-shared computer system to illustrate their use. A brief discussion is included on sequential procedures and time series methods for obtaining these estimates. The advantages and disadvantages of the various methods are given, including specific recommendations as to when certain methods might be used.

Beta Variate Generation via Exponential Majorizing Functions, Bruce Schmeiser and A. J. G. Babu, School of Industrial Engineering, Purdue University, West Lafayette, IN 47907.

Two acceptance/rejection algorithms for generating random variates from the beta distribution are developed. The algorithms use piece-wise linear and exponential majorizing functions coupled with a piece-wise linear minorizing function. The algorithms are exact to within the accuracy of the computer and are valid for all parameter values greater than one. Marginal execution times are relatively insensitive to parameter values and are faster than any previously published algorithms.

Generation of Variates from Distribution Tails, Bruce Schmeiser, School of Industrial Engineering, Purdue University, West Lafayette, IN 47907.

The well-known acceptance/rejection algorithm for generating random values on a computer is specialized for distribution tails. Using an exponential majorizing function and a linear minorizing function, the tail algorithm becomes particularly efficient. Specific algorithms are given for the normal, gamma, Weibull and beta distributions. While the algorithms can be used alone, it is anticipated that their major value will be to serve as components of algorithms for complete distributions.


This paper contains an introduction to the selection and use of simulation languages for digital computers. The topics discussed are the hierarchy of computer languages and their relationship to simulation, the advantages and disadvantages of using simulation languages, the factors to consider in selecting simulation languages for an organization and a language for solving a specific problem, some characteristics of the simulation languages GASP, GFSS, SIMSCRIPT, SIMULA, and SLAM, and future developments in simulation languages. The emphasis is on discrete and combined simulation languages.

A Stopping Rule for Data Collection in Queueing Simulations, Veena G. Adlakha and George S. Fishman, Curriculum in Operations Research and Systems Analysis, University of North Carolina at Chapel Hill, Chapel Hill, NC 27514.

This paper proposes a stopping rule (Rule 2) for terminating data collection in a queueing simulation experiment. The appeal of the rule lies in the fact that data collected in this way can be used to compute interval estimates with coverage rates that compare favorably with theoretically specified rates. The rule relies on a comparison between a priori information on the activity level (traffic intensity) \( p \) and a corresponding sample estimator computed during the course of simulation. Experiments with simulations of the M/M/c queue with \( \lambda = 1.2, 1.4, \) and \( p = .7, .8, .9, .95 \) were conducted to evaluate the rule. The experiments used a starting rule (Rule 1) proposed in Adlakha and Fishman (1979) to reduce bias due to the initial conditions and also used the autoregressive method to obtain interval estimates of the steady-state mean. For \( p = .7, .8, .9 \), the coverage rates are close to the specified theoretical coverage rates and are higher than those reported in the literature for other methods of interval estimation. The data reveal a degradation in the coverage rate for increasing values of activity level. For \( p = .95 \) the coverage rates are somewhat lower than those expected theoretically, indicating room for some improvement in technique. The sample sizes used to obtain the coverage rates are moderate and are insensitive to variation in the number of servers and the activity level. The rule can be easily generalized to a wider class of queueing simulations. Furthermore, experiments with a fixed truncation starting rule and a fixed sample size stopping rule clearly demonstrate the superiority of using Rule 1 and Rule 2 together. This is very encouraging, for it indicates a procedure now exists for controlling the detrimental effects of initial conditions and skewness on interval estimation in queueing simulations.

A Starting Rule for Data Collection in Queueing Simulations, Veena G. Adlakha and George S. Fishman, Curriculum in Operations Research and Systems Analysis, University of North Carolina at Chapel Hill, Chapel Hill, NC 27514.

This paper proposes a rule for determining when to start collecting data in a queueing simulation. The rule is designed to reduce dependence between the empty (queue) and idle (servers) initial conditions and the collected sample record. The rule is an outgrowth of earlier work by Fishman and Moore (1978) and relies on a comparison between a priori information on the activity level (traffic intensity) and a corresponding sample estimate computed during the course of simulation. Experiments with simulations of the M/M/c queue with \( \lambda = 1.2, 1.4, \) and \( p = .7, .8, .9, .95 \) reveal that the rule reduces and in most cases removes the dependence on the empty and idle initial conditions. In particular, the rule begins data collection when the simulation is in a congested state or in the steady state. The rule is well behaved in that it has low probabilities of requiring long runs before data
collection is started, although our data suggests an association between the rule’s performance and activity level, the performance is insensitive to variation in the number of servers. Since the rule is based upon the activity level, a parameter that frequently can be computed from the input parameters of the simulation, the rule is easily generalized to a wider class of queueing simulations. A subsequent study (Adhikary and Fishman 1979) demonstrates the appeal of the starting rule when used with a proposed stopping rule for computing interval estimates of parameters of interest.

Multivariate Modeling in Simulation: A Survey, Bruce Schmeiser, School of Industrial Engineering, Purdue University, West Lafayette, IN 47907, Ram Lal, Department of Operations Research and Engineering Management, Southern Methodist University, Dallas, TX 75275.

Modeling of correlated random variables is surveyed, with emphasis on non-negative random variables and quality control and reliability contexts. Particularly of interest is the use of multivariate input models for digital computer simulation. Both sequential (time series and point processes) and non-sequential systems are considered.

Analysis of Simulation with Common Random Numbers: A Note on Heikes et al. (1976), Jack P. C. Kleijnen, Department of Business and Economics, Katholieke Hogeschool Tilburg, Tilburg, Netherlands.

If different random number streams are used then traditional Analysis of Variance can be applied, but the standard errors of the estimated effects should account for heterogeneity of variance. If common random numbers are used then the quite complicated procedure proposed by Heikes et al. in 1976 may be replaced by the simple Student t-statistic combined with the so-called Bonferroni inequality. The statistical techniques are illustrated with a simple case study.

Regression Analysis for Simulation Practitioners, Jack P. C. Kleijnen, Department of Business and Economics, Katholieke Hogeschool Tilburg, Tilburg, Netherlands.

Based on elementary regression analysis as found in standard textbooks and computer software packages this tutorial presents some simple extensions useful in the analysis of simulation experiments. In simulation one usually has variance estimates (standard errors) available. These estimates often conflict with the assumption of constant variances maintained in elementary regression analysis. Therefore two options are available: (1) Switch to Generalized Least Squares, (2) Continue to use Ordinary Least Squares. The consequences of both approaches are surveyed. How to test the model’s adequacy is discussed in detail.


An algorithm is developed for optimizing the response function of simulation models with stochastic behavior. Principles of stochastic approximation are used which guarantee convergence to the optimum, if a large number of observations are made. The algorithm can be used when the decision variables are subject to a set of linear constraints.

A Design of Experiments Approach to the Evaluation of the Effects of Initial Conditions and Run Length in Simulation Experiments, Robert J. Hannan Jr., M. S. Thesis, School of Industrial Engineering, Purdue University, West Lafayette, IN 47907.

This thesis treats initial conditions, run length and replication as factors in the design of the simulation experiment. Two designs were used for this purpose: (1) the completely randomized design; and (2) the randomized complete block design. The objective of the research was to determine if either design is sensitive to the effects that are present.

CANSAM: A Simulation Model for Computer-Aided Manufacturing Systems, Jeffrey A. Runner, M. S. Thesis, School of Industrial Engineering, Purdue University, West Lafayette, IN 47907.

A Q-CERT simulation model was developed to analyze Computer-Aided Manufacturing Systems (CAM). A currently existing CAM system was studied which consists of nine (9) numerically controlled machines and an automatic inspection station linked together by an addressable pickup and delivery cart type transport system. A detailed analysis of the system is included.

Incorporation of Database Concepts into Simulation Modeling, Charles Robert Standridge, Ph. D. Dissertation, School of Industrial Engineering, Purdue University, West Lafayette, IN 47907.

A database system tailored for use in simulation modeling has been designed and implemented in the FORTRAN computer programming language. This system is a tool for use by simulation modelers in the organization, storage and retrieval of all data concerning a simulation study.

Variance Reduction Techniques for the Simulation of Queueing Networks, James Reed Wilson, Ph. D. Dissertation, School of Industrial Engineering, Purdue University, West Lafayette, IN 47907.

This research formulates, implements, and experimentally assesses procedures for applying two variance reduction techniques (poststratified sampling and control variates) in combination with two confidence interval estimation techniques (replication and regeneration in the simulation of queuing networks.) On the basis of the experimental results, guidelines are formulated for the effective application of the developed procedures in practical queueing simulations.

The Use of Cutsets in Monte Carlo Analysis of Stochastic Networks, C. E. Sigal, A. A. B. Pritsker, and J. J. Solberg, School of Industrial Engineering, Purdue University, West Lafayette, IN 47907.

Monte Carlo methods utilizing a new network concept, Uniformly Directed Cutsets (UDCs), are presented for analyzing directed, acyclic networks with probabilistic arc durations. The procedures involve sampling arc values for arcs not on a UDC and utilizing known probability information for arcs on a UDC. This approach results in less sampling effort and less associated variance than a straightforward simulation approach. A proof of this variance reduction is offered. The procedures provide estimates for project completion time distributions, criticality indices, minimum time distributions and path optimality indices. All of these network performance measures are useful to decision makers in project planning. Application areas include PERT-type network planning, equipment replacement analysis, reliability modeling, stochastic dynamic programming, and maximal flow problems.
Current Issues in Computer Simulation (Academic Press, NY 10003), Nabil R. Adam, Graduate School of Business Administration, Rutgers University, New Brunswick, NJ 08903; Ali Dogramaci, School of Engineering and Applied Science, Columbia University, New York, NY 10027.

This book is a collection of previously unpublished papers on computer simulation methodology and applications. The papers included have been reviewed by two to five referees. Each paper constitutes a chapter. The book is divided into three parts: (1) computer simulation languages, (2) simulation applications, (3) statistical aspects of simulation and linkage with optimization and analytical models. Each section starts with an introductory chapter that helps relate the different chapters included in this section to each other and provides a frame of reference to the reader.

The first part includes chapters on three of the most widely used simulation languages: GPSS, SIMSCRIPT, and GASP. The developers of each of these languages present their own account of the language’s present state as well as their ideas for possible future research and development. This part also includes chapters on the following language related issues: (1) The future event set algorithms for simulation of closed queueing systems; (2) model development and documentation standards in discrete event simulation.

The chapters included in the second section illustrate the application of simulation to diverse applications including marketing, corporate planning, hospital facilities, and computer networks.

The chapters presented in the final part focus on the following topics: (1) the linkage between simulation models and analytical and optimization models; (2) three statistical issues in simulation: variance reduction techniques, random numbers generation for bivariate and multivariate distributions, and experimental design. A chapter on concepts related to efficient and effective use of simulation in studying inventory systems is also included in this part of the book.
BIBLIOGRAPHY ON FUTURE EVENT ALGORITHMS
(January 1980)

William M. McCormack, Virginia Polytechnic Institute & State University and
Robert G. Sargent, Syracuse University


BIBLIOGRAPHY ON RESEARCH AND DEVELOPMENT SYSTEM DYNAMICS
(October 1979)

Edward B. Roberts, Massachusetts Institute of Technology

1. R&D Projects


Watanabe, K. 1964. Industrial dynamics applied to research and development. Industrial Engineering (Japan), 6, No. 12, 995-999.

2. R&D Organizations


3. R&D and the Company as a Whole


4. Other Related Areas


Bibliography on Research and Development
System Dynamics
TIMS College on Simulation and Gaming


*Copies of M.I.T. theses may be obtained in microfilm or Xerox form by direct order from the M.I.T. Microreproduction Laboratory, Room 14-0551, Cambridge, Massachusetts 02139.
BIBLIOGRAPHY ON VALIDATION OF SIMULATION MODELS
(January 1980)

Osman Balci and Robert G. Sargent, Syracuse University


SIMULATION AND GAMING
ON
TIMS COLLEGE
NEWSLETTER OF THE
College on Simulation and Gaming
THE INSTITUTE OF MANAGEMENT SCIENCES