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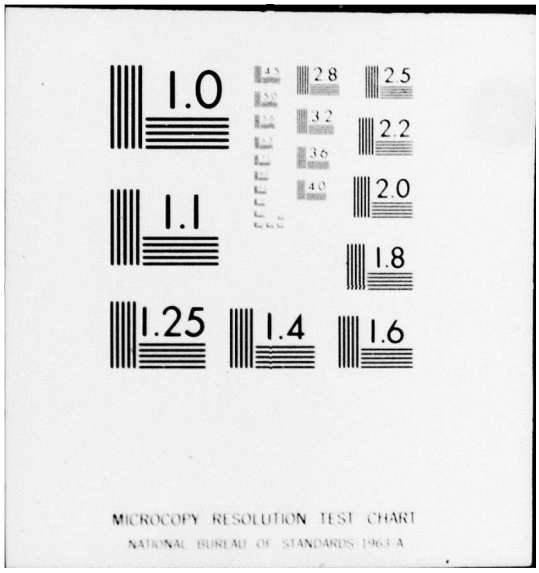
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This report describes the progress made under contract N00014-75-C-0266, project no. NR 049-345 during the period April 1, 1977 through March 31, 1978. Included are the description of the reports distributed, activities undertaken, and activities of the personnel supported by the contract.

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ANNUAL REPORT

for the period

April 1, 1977 - March 31, 1978

Principal Investigator: Bennet P. Lientz
Graduate School of Management
University of California, Los Angeles

Contract No.: N00014-75-C-0266

Project No.: NR 049-345

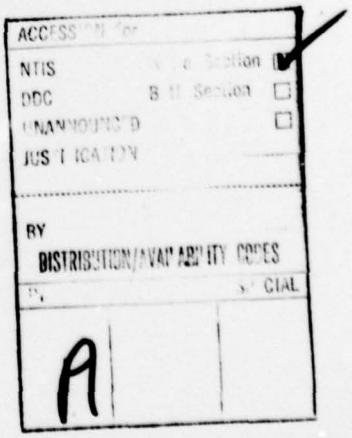
Information Systems Program
Office of Naval Research
Arlington, Virginia

Date Prepared: March 15, 1978

This report describes the progress made under contract N00014-75-C-0266, project no. NR 049-345 during the period April 1, 1977 - March 31, 1978. Included are the description of the reports distributed, activities undertaken, and activities of the personnel supported by the contract.

The reports produced during this period included the following:

1. Lientz, B.P., "A Multistage Model of Network User Behavior," (previously entitled "A Multistage Model of Network Usage,") Proceedings of National Conference on Information Systems Development, 1978, 74-78, Tucson, Arizona.
2. Lientz, B.P. and I.R. Weiss, "The Vulnerability of Computer Auditing," CPA Journal, March 1977, 47, 17-21.
3. Lientz, B.P., "Modified Bayesian Procedures in Reliability Testing," Theory and Applications of Reliability, Academic Press (C. Tsokos, I. Shimi, eds.), 1977, 163-171.
4. Lientz, B.P. and I.R. Weiss, "Trade-offs of Secure Processing in Centralized versus Distributed Networks," Computer Networks, February 1978, 2, 22-32.
5. Lientz, B.P. and J.L. Arnold, "Computer Software Selection - Some Proposed Guidelines," California CPA Quarterly, June 1977, 45, 22-26.
6. Ewusi-Mensah, K. and B.P. Lientz, "On the Application of Peak Load Pricing to Computer Services," (submitted to Communications of ACM).
7. Lientz, B.P., "Some Results on Complex, Softly Defined Problems," (submitted to Management Science).



The first report presented a life cycle model for the usage of a computer network from a user's point of view. The model was developed after a survey of several networks user organizations. Another report in the area of computer network is the fourth report. This report presents trade-off analysis to determined under what levels of degradation economies of scale of centralized facilities are compromized when a part of the workload is secure. A third paper ~~(number 6)~~ deals with the construction of peak load pricing models. The work is based in part on previous work in the electric utility industry.

Two papers deal with auditing and selection problems from a control and management point of view. The first (#2 - Lientz and Weiss) develops a framework for addressing the limitations of computer auditing. The second (#5 - Lientz and Arnold) presents selection and evaluation procedures for procuring an application software. It is currently in use by groups at several companies. The paper which appeared in the Theory and Applications of Reliability, (#3 - Lientz) presented a modified Bayesian statistical approach for reliability acceptance testing. The paper (#7 - Lientz) develops a pattern recognition approach for dealing with multiattribute decision trade-offs. It then applies the method to a complex radar system.

A paper written in the previous contract period is in the print queue at the Communications of the ACM, titled "Characteristics of

Application Software Maintenance," it presents analysis results obtained from a previous, more limited sample of organizations. It will appear in July issue of the Communications.

A major area of effort during the past year has been the collection and analysis of data relating to application software maintenance. Cooperation and support was obtained from the Data Processing Management Association (DPMA). The Association endorsed the survey, provided a cover letter, and supplied a randomly generated membership subset on preprinted labels. Response rate was out of 2000 (over 24%). This is an excellent percentage given that we resorted to bulk mailing and other means to reduce costs. These factors tend to depersonalize the questionnaire and reduce the likelihood of response. The data was keypunched through facilities provided by UCLA and the Atlantic Richfield Company. After verification and corrections the initial set of analysis were made to provide descriptive statistics of the sample. The remainder of this discussion highlights some of the findings. This part is being written up for submission to the DPMA's journal Data Managment.

Initial analysis of the results indicate that the major perceived problem areas are in the following areas:

- user demands for enhancements
- competing demands for maintenance programming personnel time
- quality of application software documentation
- inadequate training of user personnel

An area ranking lowest as not being a problem was the lack of user interest in the application system.

Preliminary analysis also indicates that productivity tools are not widely used in development - even in recently developed systems.

With respect to the sample there is a good spread by industry category. Sufficient data exists to separate government, insurance, and several manufacturing categories for comparison against the sample.

With respect to demands on resources respondents felt, on the average, that maintenance and new development are approximately equal. With the weighting slightly toward new development. The majority of the sample felt that maintenance problems were at least substantially more difficult than those in new development.

With respect to staffing over 60% of the sample felt that they were at least somewhat understaffed. This is also the case for the computer budget categories. There is also a wide variety of application systems considered. The leading applications were billing/invoice (9%), inventory control (5%), order entry (7.5%), payroll (10%). In later analysis there will be aggregated on the basis of system characteristics for comparative analysis.

Further work will be done in analyzing the data using the SPSS and BMD statistical libraries. In addition one area that has already

been identified is that of managing and keeping up with changing user requirements. One area of research in the next contract period will be aimed at starting to develop methods for tracing and managing requirement changes. Several organizations have indicated a willingness to be supportive by serving as a test sites.

The other major activity is in the area of computer networks and distributed systems. On the application side the computer network model was installed at an Air Force facility on a Hewlett-Prckard 3000 Series II, Model 9 minicomputer. Trade-off analysis was done for several configurations. Installation and analysis was supported under a short term Air Force purchase order.

A focus of the research was on the development of pricing models for computer networks. This work and its background is described in the paper, "On the Application of Peak-Load Pricing to Computer Services" (K. Ewusi-Mensah and B.P. Lientz). Peak loads for computer systems have been a recognized problem for some time in the literature. Computer networks offer the benefits of load sharing. The research here aims at developing pricing strategies for a variety of conditions and goals.

Models have been developed for profit maximization, revenue maximization, and maximization of a function of usage. The methods developed involve fewer assumptions than those in literature. The technical approach is drawn from the work in economics for public utilities and peak load pricing. A mathematical programming approach used with Lagrangiun Multipliers. Subcases are considered for independent and dependent demands between periods.

Validation of the model was performed using two computer complexes with different objectives - one at at university and one at a corporation.

Monte Carlo simulation was necessary to estimate the price and cross-price elasticities of demand. In the next contract period an effort will be made to improve the model and to collect historical data on a wider base for validation of subcases.

With the spread of computer-communications a problem of some interest is the relationship between the user and provider of computer services. A service model has been developed by a Ph.D. student, Mr. Stephen Kwan. The effort of research in this area is to develop a service approach for allowing users to perform trade-offs in processing priority and cost. Data has been collected from TRW Systems to support this analysis. This work will be completed in the next contract period.

A separate but related area in computer networks is the analysis of user behavior. A life cycle model was developed in "A Multistage Model of Network User Behavior." Three stages were proposed - inception, growth, and stability. Case studies were presented and analyzed. Current research is focused on using time series analysis to determine stopping rules for monitoring and controlling the growth stage.

The people supported under the contract were Professor Bennet P. Lientz, Principal Investigator, and Professor E. Burton Swanson. In addition the following doctoral students worked on the project, but required no Office of Naval Research contract funds; Kweku Ewusi-Mensah, Kurt Fischer, Steve Hug, Steven Kwan, and Gerry Tompkins.

Dr. Tompkins graduated in Summer 1977 from UCLA and is now a research scientist at IBM's San Jose research faculty. His area of interest is the analysis of application software maintenance.

Messrs. Fischer and Kwan expect to complete their dissertations by Summer 1978. Mr. Fischer's area of research is that of the minimization of retesting during software maintenance. Mr. Kwan's research is modeling the interface between computer users of a network and the management of the network. Mr. Fischer will be joining Computer Science Corporation as as Senior Scientist. Mr. Kwan has accepted an Assistant Professorship at Boston University.

Dr. Ewusi-Mensah received his Ph.D. in the area of pricing of computer network services in Winter 1978. In particular his work focused on developing a peak load pricing model and its subsequent validation.

Mr. Hug expects to be advanced to candidacy for the Ph.D. degree in June 1978. His intended dissertation area is the of computer auditin of minicomputers.

Professor Swanson was advanced to Assistant Professor, Step IV. In addition to his work on the maintenance area he presented papers at the Joint TIMS/ORSA National Meeting, San Francisco and at the Data Processing Managers Association. He also had an article appear in the Journal of the American Society for Information Science, September 1977.

Professor Lientz was advanced to Step III Associate Professor. In addition to the publications cited previously, he was elected to be a Director of the EDP Auditor's Association. He is also a Session Chairman and Publicity Chairman of the 1978 ORSA/TIMS annual meeting. He has been listed in Contemporary Authors and Who's Who in the West. He continued as Associate Editor of Computer Networks and was a reviewer for several journals. He was an invited speaker at meetings of the Society of Management Information Systems, the EDP Auditor's Association, and the ISI meetings in India. He served as Academic Assistant to the Chancellor for computing policy at UCLA. His recently completed book - Systems in Action: A Managerial and Social Approach has just appeared in print.