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April 1, 1978 through March 31, 1979

Contract No: N00014-75-C-0266 NR-049-345 Project No: Information Systems Program Office of Naval Research

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This report summarizes the work during the period April 1, 1978 through March 31, 1979 under contract N00014-75-C-0266. The persons supported during this period were Professor Lientz, Professor B. Swanson, several Ph.D and Masters students (Dr.Kweku Ewusi - Mensah, Mike Levy), and secretarial support.

The reports produced during this period were as follows:

- 1. Lientz, B. P. and E. B. Swanson, "Discovering Issues in Software Maintenance, Data Management, Vol. 10, pp. 15-18, 1978.
- 2. Lientz, B. P., E B. Swanson, and G. L. Tompkins, "Characteristics of Application Software Maintenance," Communications of the ACM, Vol. 21, pp. 466-471, 1978.
- 3. Lientz, B. P. "A Multistage Model of Network Usage," Isletme Dergisi, Vol. 4, pp. 193-203, 1978.
- 4. Lientz, B. P. and M. Chen, "A Methodology for Long Range Information Services Planning," Long Range Planning, (to appear in Summer 1979).
- 5. Lientz, B. P. and E. B. Swanson, "On the Use of Productivity Aids in System Development and Maintenance," submitted to International Conference on Software Engineering, 1979.
- 6. Lientz, B. P. and E. B. Swanson "A Survey of Application Software Maintenance," Data Management (to appear in 1979).
- 7. Ewusi-Mensah, W. and B. P. Lientz, "On the Application of Peak Load Pricing to Computer Services," submitted for publication.
- 8. Lientz, B. P. and I. R. Weiss, "Trade-Offs of Secure Processing in Centralized versus Distributed Networks," Computer Networks, Vol. 2, pp. 35-43, 1978.

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The publications highlight the major areas addressed in the research program: computer-communication systems and software maintenance. In the computercommunication area the work addressed applying a simulation model to demonstrate the ability to do trade-off analysis between security measures and computer performance, in terms of throughput and response time as well as cost (6). Additional work was done in the area of peak load pricing of network services (7). The emphasis here is to derive models for developing pricing policies using economic theory. In (3) a life cycle model is presented for the use of timesharing and interactive systems.

The major current effort is in the application software maintenance area. Data collected by an extensive survey has been analyzed and several reports have been produced. Lientz and Swanson (1) discuss software maintenance issues. The tabular results of the survey appear in (6).

One particular area of interest is the use of productivity aids. This has been documented in (5) and is being considered for presentation at the International Conference on Software Engineering. Another paper that is being developed reports the use of factor analysis in determining problem areas that affect maintenance effort. Analysis indicates that the predominant group of factors involve user needs, expectations and participation. The second group of factors involves management issues -- resource allocation, etc. The third group consists of technical issues, documentation, etc.

The pilot survey reported in (2) consisted on the first phase in maintenance. The second phase which included the expanded survey as reported in (1), (5), (6) provides an overall view of maintenance. Current effort has several foci:

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- Continuation of analysis of data

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- application to real DeD. Systems

- research stemming from survey work

The first of these has been addressed. The second area has begun. With the help of ONR staff members, contact was established with a maintenance group of the U. S. Marine Corps at Camp Pendleton, California. An initial visit was made. Results of the survey were presented. It is intended that this will be followed up by an exchange of documents and then by assistance to them in analyzing their current maintenance effort. Additional visits will be made in the next contract period.

Several areas of research have emerged from the survey work. One area is that of planning to control maintenance effort. This is reported in (4). It will be expanded to provide a methodology for development and maintenance in the next decade. A second area is that of creating and monitoring system requirements across the life cycle. This is being worked on. The third area is that of software cost estimation. The initial estimation effort will be in the maintenance area. It will consist of a classification method of systems change requests and measurement. If this is successful, an attempt will be made to extend the method into development.

During the year, a number of papers were presented. Professor Lientz presented invited papers at the EDP Auditors Association, the ORSA/TIMS annual meeting and the Data Processing Management Association (DPMA). Professor Swanson presented invited papers at the Systems Science Symposium, the TIMS-ORSA meeting, and the DPMA.

The remainder of this report summarizes some of the recent analysis of the maintenance survey data. The questionnaire asked managers to respond to a variety of problem factors as well as to the extent of maintenance. orm problem factors accounted for 88.9% of the problem variance using factor analysis. These were

- programmer effectiveness (r=.191, s=.001)
- product quality (r=.191, s=.001)
- user knowledge (r=.113, s=.006)
- programmer time availability (r=.101, s=.013)

Here r is the correlation measure and s is the significance level. Two other factors, system reliability and machine requirements, were less significant. Each of these factors is a cluster of specific problem areas identified in (6).

The problem area groupings are:

- user knowledge

 programmer effectiveness

- product quality

 programmer time availability

- lack of user understanding
- inadequate user training
- maintenance programmer productivity
- maintenance programmer motivation
- skills of maintenance programmers
- adequacy of system design specifications
- quality of original programming
- documentation quality
- competing demands for maintenance time
- machine requirements

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- program storage requirements
- program processing time requirements

Using analysis of variance, the six problem factors were considered against the level of staffing sufficiency and the demands of maintenance on the manager's own time. It was found that four problem factors varied significantly by perceived level of staffing sufficiency:

- user knowledge (s=.007)
- programmer effectiveness (s≤.001)
- product quality (s 2.001)
- programmer time availability $(s^{\leq}.001)$

For demands on the manager's own time, four factors varied significantly:

- user knowledge (s=.005)
- programmer effectiveness (s[≤].055)
- product quality $(s \le .001)$
- -system reliability (s=.076)

These results indicate that system reliability and machine requirements have a lesser effect. Several potential reasons for this are improved price performance of hardware, migration support to new hardware systems, and age indicating system stability.

Analysis was performed to see if system size and age have an influence on the perceived problems of maintenance. It was shown that age and size impact the magnitude and allocation of maintenance effort as expected. Size has no impact except for only machine requirements and system reliability. However, these accounted for only 11.1% of the total problem variance. System age had no notable influence on problem factors whatsoever.

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Analysis of variance was performed for the six problem factors and system development tools. Of these factors product quality was affected by test data generators, structured walk-through and chief programming team. However, it is noteworthy that the problems of user knowledge and programmer effectiveness, which account for 71.4% of the total problem variance, are little affected through the use of these techniques. Separate analysis revealed that greater problems of system reliability are seen to be associated with a data base dictionary. This may, perhaps, reflect the complexity of the system software incorporating the tool. No significant variances were found when the six problem factors were analyzed with the use of a data base management system.

It has been argued in the literature that maintenance effort depends on the choice of language. Using one way analysis of variance two factors were seen to vary significantly with language. These were programmer effectiveness (s=.010) and system reliability (s=.080). For programmer effectiveness problems tend to be greater than average where assembler languages are used and notably greater than average for PL/1 and FORTRAN. For RPC it is less than average. COBOL is average. This is not entirely unexpected since sophistication in a language may affect programmer effectiveness.

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