The Engineering of Software: A Startling Contradiction

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"The attempt to build a discipline of software engineering on such shaky foundations must surely be doomed, like trying to base chemical engineering on the phlogiston theory, or astronomy on the assumption of a flat earth."

The Comparison of Ideals

If words could cure the ills of our profession of programming, what a healthy and highly respected profession it would now be! We have had "modular programming"; the craze for "structured programming" has hardly yet reached the height of its commercial profitability; and already we have a newcomer to the charts — the theme we have all so long been waiting for — yes, it's "SOFTWARE ENGINEERING". The experienced programmer will greet these tidings with a stifled yawn, and turn to more urgent and important tasks. But perhaps there is something he could learn from these catch phrases on their passage from popularity to oblivion. Certainly, the latest combination of the new but already tarnished word "software" with the old and respected profession of engineering is such a startling contradiction that it should give us pause. Let us compare the ideals of the professional engineer with those adopted by some programmers of the present day.

Ability and Understanding

One outstanding characteristic of the professional man, be he a doctor, architect or engineer, is that he understands the real needs of his client or employer, often very much better than the client himself; and he has the ability and status to persuade the client to recognize his own interests and to abandon his less useful flights of fancy.

Professional Integrity

Then he has the professional skill to recommend from a range of known and trusted techniques those methods that in the given circumstance will achieve the required effect at minimum cost and inconvenience to the client. And finally, he has the professional integrity to resign his post or commission if his recommendations are not accepted.

Resignation When Advice Not Taken

I fear that there is a sad contrast with some programmers, whose only wish is that their client should "make up his mind what he wants", and who will welcome his most elaborate fancies as a challenge to their programming ingenuity. How many of them are ignorant of, or prefer to ignore, the known techniques used successfully by others, and embark on some spatchcocked implementation of their own defective invention? And I know only one programmer who resigned on the spot when his advice was not taken by his less technically competent manager.

Reducing Costs and Increasing Reliability

A second characteristic of the good engineer is his vigilance in seeking every opportunity to reduce the costs and increase the reliability of his product. He realizes that the conflict between these two objectives can be resolved only by preserving the utmost simplicity of concept, specification, design, and implementation. Above all, he insists that he shall have a complete understanding and control over every aspect of his project — and the more difficult his project, the more firmly will he insist on the simplicity without which he cannot understand what he is doing. Here again, we find exactly the opposite characteristic in some of our best programmers, who deliberately avoid simplified solutions; they obtain satisfaction from the sophistication of their designs and methods, and derive excitement from engaging in projects of a complexity slightly beyond their ability to understand and control. They may well succeed once; but on the next occasion they may discover that there is no way of distinguishing (in advance) between what is slightly and what is totally beyond their comprehension.

Sound Theories and Techniques

A great advantage of the present day engineer is that his designs are based on sound mathematical theories and computational techniques, discovered over the years by his brilliant predecessors, and now enshrined in textbooks and undergraduate teaching, in mathematical tables, and in standard codes of practice. But in spite of the soundness of his theory, he still has many causes for worry that his abstractions (and his product) may break down — a faulty casting, a defective batch of components, a lazy workman, or an unpredictable natural hazard.

The computer programmer has little worry of this kind: his working material is the hardware of the computer itself, and its reliability can usually be taken for granted. Certainly, by far the most significant cause of failure in software is the errors and oversights of the programmer himself. But here perhaps he is not wholly to blame, since he has no widely accepted mathematical or theoretical founda-

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COMPUTERS and PEOPLE for July, 1976
Universal Vendor Marking (UVM): A Missing Link

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"In short, UVM will reinforce the basic mission of all retail organizations—that is, buying and selling merchandise more efficiently, and thus more profitably."

A Universal Standard for Marking

No recent development in the retail systems field is more revolutionary than the selection of a Universal Vendor Marking standard. As an equipment manufacturer, I realize that a new standard remains meaningless until it is actually implemented. And I view the Optical Character Recognition (OCR-A) standard to be so important—to the retail industry, to merchandise manufacturers, to equipment suppliers, and to the shopping public—that I want to do what I can to assist in its implementation.

An Old Standard Awaiting Advances in Wand Technology

Although OCR-A offers great potential for almost every facet of retailing, it is not a new and untested concept. It was adopted as a U.S. general-purpose data processing standard in 1956—10 years ago—and as a national data processing standard in 1969. However, its practical application at the retailer’s service advances in wand technology, which have hitherto occurred.

The UVM program being launched currently is due to the efforts of those who are responsible for the industry-wide mark standard, and who thus spearheaded the adoption of such a standard. Certainly we are all, and the public, the to the forefront of the efforts of the Manufacturers Technical Advisory Committee of the Computer and Business Equipment Manufacturers Association; to the NERA Systems Specifications Committee to which the merchant vendors who are well along in their planning for UVM; and to many others, together.

They have created a merchandise identification system which is technically sound and economically feasible. In doing so, they have given us as a way of forging the missing link—in a claim recognition and reference advances which can now make automation into a new and more productive era.

Reasons for Support

There are compelling reasons which cause the equipment manufacturer to support the new universal standard:

- It is a standard chosen and promoted by NERA rather than by a single equipment manufacturer; hence, it is a standard which everyone can support.
- It is a fact that it is human-readable as well as machine-readable offers both internal system benefits and external customer benefits.
- It is a standard which can be printed by relatively inexpensive printing mechanisms of many different types. Thus, it can be implemented at less cost than systems based on print/ punched, bar code, or magnetic stripe.
- Finally, it can be used with virtually any retail medium including credit cards, invoices and other control documents.

At first glance it might seem paradoxical that manufacturers of retail point-of-service equipment several of which developed their own computerized systems for merchandise marking—now endorse a Universal Marking standard. In fact, no paradox exists. Before OCR-A, equipment manufacturers moved in the only direction they could move—in order to meet the pressing need for automated data input: each manufacturer developed his own standard.

Now that situation has changed—and for the better. With an industry-wide standard, the equipment supplier no longer has to manufacture hardware that is compatible with supporting different systems. In other words, the software problem is also simplified. We recognize that implementation of the new universal standard will ultimately provide a much broader market for scanning systems, which in turn will result in lower-cost equipment for our customers.

Scanning Equipment Costs

It has been said that scanning equipment is too expensive for widespread use in the general retailing field. It is good to remember that the first computers used in retailing were also expensive. Yet today they are a basic computer component of almost every retailing establishment. On the same basis, new technology will be constantly bringing down the cost of equipment and accessories to the point of increasing volume, as scanning becomes widespread, and the cost huggates begin to look rather innocuous.

These are a few of the reasons why the equipment manufacturer is willing to work with everybody and anybody to accelerate the implementation of the Universal Vendor Marking standard. It seems to me that such a standard will be attractive to the general merchandise retailer and to merchandise vendors.

Inventory Control at the Unit Level

From the standpoint of the retailer, UVM gives the merchant a powerful new tool for achieving inventory control at the unit level. However, in contrast to the dollar level, thereby helping to improve return on inventory investment. As we all know, the potential benefits of unit control have long been apparent. Yet for most stores it has been an elusive target. The missing link has been a fast, easy, accurate and low-cost method of capturing the data required to keep track of individual merchandise movement from the point-of-order to the point-of-sale. OCR-A can help make that possible.

And because scanning enforces accurate data capture, it can overcome—once and for all—the perennial problem of lost or misplaced tickets that for so long has frustrated the retail systems designer. It is ironic that 25 years after the development of bar coding, block books are still in daily use because buyers so often lack confidence in computer reports, which of course can be no better than the data upon which they are based.

Speed of Scanning

Equally attractive, from a systems standpoint, is the speed with which OCR-A media can be scanned. This makes it economically feasible to get all the information needed—and to get it right. Last but not least, because increasing merchandise to the selling floor faster, by reducing the burden of store-level marking, is a key consideration when capital is both expensive and hard to get.

In short, UVM will reinforce the basic mission of all retail organizations—that is, buying and selling merchandise more efficiently, and thus more profitably.

Its advantages to vendors are also significant. They include a faster and more accurate fulfillment of orders, and more timely feedback on product reception in the marketplace. In addition, UVM will simplify the marking task itself. This is already occurring in the food industry as a result of that industry’s adoption of its Universal Product Code.

The Consumer’s Stake

And what about the consumer? What is he stake in this program? I think his stake is very important because UVM can mean new levels of shopping convenience, and the efficient reduction of purchase and order errors, it should also result in a better selection of merchandise, by dramatically reducing out-of-stock situations.

The advantage of UVM as seen by the equipment manufacturer are real, and therefore our respective interests should be getting behind the UVM implementation program. But we should remember that the most accomplished to date is the easiest part of the task. The most difficult part is still to come.

The Remaining Challenges

What, then, are the remaining challenges confronting our three industries—individually and collectively?

For the equipment manufacturers, there is a need to acquire additional experience with the new NERA standard by installing working systems in a variety of retail environments, for example, Dick’s first step in this direction last year with the installation of an OCR-A scanning system in a J.C. Penney store in Pekin, Illinois. This application is in the in-house merchandise marking by Penney personnel.

Next month another milestone in the UVM implementation program will be reached when for the first time a major merchandise manufacturer, the LTV Stores, a subsidiary of LTV 6 Co., will begin a vendor marking program for Penney’s of Houston. Several other merchandise manufacturers will launch similar efforts in the near future. Thus, 1976 should prove to be a very spectacular year, with the new standard a paper tiger that will never get off the drawing board.

Marketing of New OCR-A Systems

So far as equipment manufacturers are concerned, our company and no doubt others as well, will begin marketing OCR-A systems this year. We will be working closely through the Manufacturers Technical Advisory Committee—with both retailers and merchandise manufacturers in resolving any questions as they arise.

I believe this year will see an equally vigorous implementation effort on the part of retailers. Certainly every major retail organization interested in OCR-A will see its future systems program will want to get some first-hand experience in the OCR-A environment. Starting such a program now, with a limited in-house marking operation, will provide valuable guidance for planning future programs. In short, it will produce immediate benefits in the form of additional merchandising efficiencies.

Implementation

Merchandise manufacturers now have a green light for planning their inventory control marking system. The question is: will they take the lead, and will they take the lead, and will they become part of the OCR-A group? I am pleased with the progress that has been made by the sewing industry. I think that the toy industry, for example, would be well advised to take advantage of the opportunity to standardize.
Computers and Society: A Theme for a Course and a Final Examination

Edward C. Berkeley
Editor, "Computers and People"

"What are the 9 to 12 most important problems to be solved if human beings are to survive on the Earth for the next ten thousand years? What would be your detailed recommendations as to the use of computers to define the problems and to compute solutions to these problems?"

Walter J. Freeman, formerly of "Computerworld" and now of American Data Computer Corporation, and I gave a half-year course at Boston University, Boston, Mass., from February to May 1976, to some forty students who were candidates for a master's degree.

The main theme of the course was this:

Imagine your future role, as a result of this course, as that of an advisor or consultant to a government commission. What should you know about the computer in terms of its uses and soci-ety? What advice should you be able to give as to things to do and things not to do?

The final examination (three hours) was drawn from the following set of questions:

1. Good Advice. Mr. James Jones, president of the Jones Co., a small business with 30 employees, has acquired in business for 20 years, and has decided to "get started" in computer data processing. Mr. Jones, an equipment salesman (knowing that you have a master's degree in computer science from B.U.),

Can you see me next Thursday afternoon, spend a couple of hours with me, and guide me with your professional knowledge— and if you don't agree to accept my check for your consulting, I'll ask somebody else.

State all the points and the "good advice" which you would give him.

2. "Undisputed." The City of vast Population 2/4/day, population 2/4/day, population 2/4/day, population 2/4/day, population 2/4/day, population 2/4/day. There is an extensive set of small and large city computing centers, both computerized and non-computerized. A local city council, in the question of whether or not to computerize their cadastre, appears to be significantly interfering with expansion of the computerized data processing systems. The city council has decided to hire an economist to reduce the argument. Prepare a good set of guidelines for the economist, dealing with both formal arguments and recommended behavior.

3. Computers and Privacy. Much discussion, argument, and debate, regarding governmental decisions both in the United States and outside have occurred in the area of computers and privacy. State 15 of the most important points and issues.


5. Limits to Growth. A governmental commission has been appointed to consider "the limits to growth." The thesis that in 20 to 150 years the countries of the world will hit some hard obstacle to economic growth and expansion, a condition which may be catastrophic to human society.

You have become a consultant to the commission. You are asked (a) to prepare an outline of "How can we use computers to define problems and to find solutions to problems of limits to growth?" (b) to give your recommendations for a new employment program for the displaced programmers.

Are we good? Why is this not good? Why?

6. IBM Monopoly. It is widely agreed that IBM has a monopoly position in the market of computers and data processing.

Describe this position and how IBM has been able to maintain it.


How would you define a "computer professional?"

How would you define an "educational engineer?"

Describe the differences between them. If so, what would be the differences?

What are the 11 promises included in Susskind's proposal? What are the reasons for these promises? What are the reasons against? What are the 11 promises included in Susskind's proposal? What are the reasons for these promises? What are the reasons against?

8. Brain, Thinking, and Artificial Intelligence. Define the following terms: artificial intelligence; natural (i.e., nonartificial) intelligence; commonsense; wisdom; thinking; brain.

Describe the principal features of the animal brain developed by evolution for over 500 million years up to the time of the human brain. Describe the new features exhibited by the human brain. Describe the new computer brain.

Do you consider that artificial intelligence provided by computers can be substantially solving the problems of the artificial brain? Why or why not?

9. Software Generation. A recent conference in Canada (at Stanley House, Graham, in 1975) dealt in detail with features of information systems which would make them more human—less irritating and more reasonable to human beings.

State 20 features of computerized information systems which would make them more humanized. How would you want to bring about more humanized information systems? Why these methods instead of others?

10. Education and Computers. Why do you recommend the use of the computer in education? Why these and not others?

11. Use of Computers for Critical Purposes. What is in brief the story of the Equity Funding scene? In 1970 you were associated with, you detected evidence of criminal behavior, what would you do? Why? Give 10 or more system recommendations for reducing the possible use of computers for critical purposes.

12. Computers and Employment. There is a widespread fear that the computer will replace the white collar jobs (for clerks, lower level manager, and middle man- agement) will disappear as a result of computerization.

What are the reasons for expecting this result? What are the reasons for not expecting this result?

If a process by which a computer would perform the analysis and control process were invented, and the process should displace 50 per cent of human programmers, what would you recommend for new employment for the displaced programmer?

The IBM plan was adapted in Sweden to deal with technological unemployment. What is this plan?

What are the reasons for believing that this plan will work well in the United States?

What are a dozen occupations for college graduates which will be highly resistant to technology?

13. The Most Important Problem for Human Survival on the Planet Earth. What are the 9 to 12 most important problems to be solved if human beings are to survive on the Earth for the next 10,000 years? The criteria for inclusion of a problem in this area is that the problem is not solved, human beings will become extinct.

You have become an advisor to a United Nations commission charged with defining the applications of computers in this area. What kinds of advice and recommendations do you have for the commission? What kind of advice and recommendations do you have for the commission? What kind of advice and recommendations do you have for the commission? What kind of advice and recommendations do you have for the commission? What kind of advice and recommendations do you have for the commission?

14. Computers and the Vietnam. So-called "modern" warfare, such as took place in Vietnam from 1962 to 1975, is a highly electronic and related electronic systems which compute, to a very large extent. A few applications are: guiding missiles; choosing targets; secret police systems; selecting persons for arrest, assassination, torture, imprisonment in tiger cages, etc.; gathering intelligence; the "electronic battlefield.

What are the lessons of that war in general? What are the lessons of that war in particular in regard to the application of computers?

What are the chief reasons the United States lost that war?

If you were asked to be an advisor to a military commission for the purpose of improving and extending the application of the computer to warfare, what would you do? Why?

15. Computers and the Home. What are 15 possible applications of small computers or computer terminal to the home?

Do you consider that these applications will result in a large increase of human welfare? A large market for computer products? Why? If not, why not?


"America is drifting into economic planning... Senator Robert Humphrey and Jacob Malik have joined forces to introduce a bill establishing a national economic planning commission. It is sponsored by John Kenneth Galbraith and Nobel Prize winner Musashi Toda. There are many more... and a small but growing number of business leaders..." (Proprietary planning is "must.")

Franklin and Henry Ford have spoken out for the establishment of some form of national planning."

"... and a growing economic planning will probably be a coordinated set of general economic targets; say, a 50 per cent reduction in unemployment; a reduction of trade deficits by 25 per cent; an increase of the rate of economic growth to 5 per cent... National economic planning is an effort to coordinate existing plans... as we need to extend the reach of our control over the economy..." (In fact the big corporations in all industries act like private planning agencies, a point eloquently expressed by Galbraith. To a very great degree, the big companies hold the market at bay, using off-price inventory when they want to, not when an oceanic flood of competition forces them to. So they, too, expand (or contract) their enterprises according to long range forecasts and ignore the immediate press of business conditions."

What have you been asked to act as consultant to the National Economic Planning Board of the United States?

What classes of problems would you recommend be computerized? What classes of problems would you recommend not be computerized — i.e., leave to pen and paper, discussion by committee, etc. In other words, what should be useful applications of computers and to what kind of problems should we use computer or injudicious applications? What kinds of data would one not computerize? Where and in what areas of national economic planning would produce real and significant results?

10 COMPUTERS AND PEOPLE for July, 1976
Software and Consultants: An Introduction

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"It's important to understand how hardware and software act together. . . . Good software can often make average hardware work satisfactorily; poor software can render good hardware useless."

How Can I Best Solve My Computational Problems?

You've probably been asking yourself this question and the answer may seem fairly elusive. We have helped many organizations and businesses solve their computational problems, and we'd like to share with you some of the concerns that others have expressed.

You may be thinking in terms of selecting a computer or computing calculator; however, neither of these is a complete solution to such a task. In fact, the hardware and software interact, and the key to successful application is a combination of the best computer or computing calculator and the best software.

Hardware and Software

It's important to understand how hardware and software act together, here are the topics that need to be considered:

- Low Cost: Standardized software is used by many people, so costs can be distributed among the users.
- Reliability: Because standardized packages have been used by many other people, most of the bugs have been found and corrected.
- Immediate Delivery: Custom software has first to be developed and that can take weeks or months. Standardized software can be delivered and operating almost immediately.
- Documentation: Documentation describes the problem and provides instructions for users. Generally documentation is much more detailed for standardized software.
- Greater Flexibility: Standardized software is typically written to be flexible. Changes in data and report format can usually be made easily.

Modifying Standardized Software

Even if no standardized software packages exist for your needs exactly, minor changes can often be made to satisfy your requirements. For example, if you need a program to bill your customers on your company's invoice, you can easily modify the invoice printing program from a standard software package.

Developing Custom Software

Standardized software has many advantages, but, if you cannot find a package to satisfy your needs, you may be able to modify one or write your own. The choice depends on the amount of custom software you'll need. Many organizations that use computers exclusively employ a full-time programmer to write and maintain custom software. If your application software requirements are not too extensive, you might try to locate someone in your organization who could develop your software in addition to his present responsibilities. If you can't find someone, it may be desirable to look outside for someone who could develop custom software; for example, a software consultant.

Software

While most people think in terms of hardware, software is also vital for success. Good software can make average hardware work satisfactorily; poor software can render good hardware useless.

Standardized Software

How can you find the software you need? One of the best sources for software is the hardware manufacturer. Many manufacturers maintain standard program packages for many applications. Often you can locate the solution you need from the program library. These standardized software packages offer many advantages:

- Low Cost: Standardized software is used by many people, so costs can be distributed among the users.
- Reliability: Because standardized packages have been used by many other people, most of the bugs have been found and corrected.
- Immediate Delivery: Custom software has first to be developed and that can take weeks or months. Standardized software can be delivered and operating almost immediately.
- Documentation: Documentation describes the problem and provides instructions for users. Generally documentation is much more detailed for standardized software.
- Greater Flexibility: Standardized software is typically written to be flexible. Changes in data and report format can usually be made easily.

What is a Consultant?

A software consultant (or software house) is an independent professional who specializes in designing, writing, and supporting software. He works directly for you, not a hardware manufacturer, even though he may coordinate his work closely with a manufacturer.

The Advantages of Independent Consultants

Customers of virtually every major computer manufacturer use independent software consultants. There are many reasons why:

- Initial Analysis of Your Problem — Many companies prefer an independent consultant to help them choose a computer or make recommendations about procedures and systems.
- Application Experience — Consultants often have extensive experience in specific applications, and they may be able to provide valuable assistance.
- Multiuser Package — If you're buying equipment from many different manufacturers for an integrated system, it may be desirable to look outside for an independent consultant with expertise in your application systems.
- Your Choice of Software — The ability to choose the consultant you want gives you an opportunity to develop the best software for your specific needs.

Understanding Your Own Needs

What information about your specific requirements will you need to give your consultant or your consultant's representative? How does a computer software consultant help you? What must you know to choose the one that's right for you? There are several basic steps involved.

- Reviews of Your System — The basic review will usually require an analysis of your data to be entered. For commercial applications, where source documents are available, they will ask you for the number of samples or rough inputs.
- Input Specifications — It is important to determine the amount of information that will have to be stored. A list of your data elements, their data type, value range, and the number of occurrences is important.
- Output Specifications — What information, in what form, do you want? You should specify if your output should be on a line printer, typewriter, CRT, tape cassette, or punched tape. This will affect the systems design.
- Sample Programs — Take out your program, punch it, and make sure that it will run on the machine, or we can provide a sample of what you want.

Review Your Solution

It's very easy to neglect details. So ask your representative and the consultant to outline their proposal to management. Then, ask for suggestions. This covers many purposes. In addition to avoiding potential problems, it helps to get your staff and your management involved. By being involved, you can dispel any fears.

Here are some suggestions for items to beware of when you review your proposal:

- Potential Growth — Estimate potential growth, if your present problem involves measuring 2,000 to 3,000 or 5,000?
- Maintenance — Is it necessary to have another report or some additional information?
- Revisions of Procedures — Once you have set up your forms and procedures, you will need to help you understand and maintain your information.
Computerized Adaptive Ability Measurement—Part 2

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"Accuracy in measuring an individual's ability level can be reduced by the individual's behavior in the testing situation. Guessing, lack of motivation, frustration, boredom, and other psychological variables can add error to an individual's test scores . . ."

Some Recent Findings

Our research to date has been primarily concerned with testing the relative effectiveness and utility of the various adaptive testing strategies, and comparing ability estimates derived from adaptive tests with those from conventional tests. Live-testing studies have shown that scores derived from adaptive tests are more reliable over time than are scores from conventional tests. This higher reliability is important in any situation where measurement and greater utility in making longitudinal predictions. The simulations we have used in these live-testing studies show that the higher accuracy of measurement for the adaptive tests holds throughout the ability range for all strategies of adaptive testing studied, although some of the strategies are better than others in terms of maintaining a constant degree of accuracy throughout the ability range. Our results have also shown that adaptive test scores reflect the distribution of ability in a group better than do conventional tests.

One particularly interesting set of data resulted from a live-testing, test-retest study using the stratified test strategy. As was indicated earlier, and illustrated in Figures 2 and 3 (see Computers and People, June 1976, pp. 17 and 18), stratified tests yield "consistent" scores as well as ability level scores. These scores reflect the range of difficulty of the items encountered by an individual. One operationalization of the notion of consistency of response is the number of items used by an individual before the termination criterion is met. Highly consistent individuals use few short, and inconsistent testers encounter items at stimulus of widely differing difficulties.

The Role of Consistency and Predictability

We hypothesized that consistency should be related to reliability. Thus, the more consistent individual should be able to score within the less consistent individual less predictable. To test this hypothesis, we performed a stratified test twice to a group of individuals; an interval of about six weeks separated the two administrations. Using each test results, we determined each test's consistency score and subdivided the total group into five subsamples ranging from very high consistency to very low consistency (N = 12 to N = 36). When the group was broken up, we calculated the test-retest correlation (stability coefficient) for each of the ten methods of estimating ability with the stratified test.

The general pattern observed was in the predicted direction, although it varied for different methods of estimating ability and consistency. The closest pattern emerged for Ability Score 3 using Consistency Score 31 (see Figures 2 and 3). For the total group of subjects (N = 170) the test-retest reliability was .65. As consistency increased so did reliability. For the most consistent group, reliability was .94, while the intermediate consistency group had reliabilities of .85, .84, and .77. For other methods of scoring ability on the stratified test, reliabilities for the most consistent group were as high as .90, indicating that for this subgroup their scores on the second testing were almost perfectly predictable from their scores on the first testing. On the other hand, individuals with very inconsistent responses at initial testing generally were least predictable on retest.

These results were, of course, obtained over a rather short time interval. If they can be shown to hold over longer time intervals, they have important practical implications since they will permit us to identify individuals whose scores are a give-away test are more (or less) reliable. We will then be able to make selection, placement, and classification decisions for specific individuals taking into account the reliability of each person's test scores.

Psychological Effects

In addition to investigating psychometric variables in adaptive testing, we are also systematically studying the effects of adaptive testing on certain psychological variables. Accuracy is measuring an individual's ability level can be reduced by the individual's behavior in the testing situation. As was shown earlier, the individual's performance can be influenced by the individual's behavior in the testing situation. Given this, poor motivation, frustration, boredom, and other psychological variables can add error to an individual's test scores, which will reduce the validity of those scores for practical decisions.

Because an adaptive test maintains the difficulty of the test items at the individual's ability level, we have hypothesized that it should reduce the adverse influence of those psychological variables and thus increase the accuracy of test scores.

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These benefits should be in addition to the purely psychometric increases in accuracy due to the adaptive testing procedure. If several of these different advantages of adaptive testing procedures are all beneficial, the resulting test could be very appealing to users.

This subset of studies includes a variety of designs which are currently being pursued. In one study, we are concerned with increasing the accuracy and efficiency of the testing procedures with new test items. In another study, we have focused on the application of different psychological variables to the design of tests. In this study, we are using the effect of adaptive testing on test scores as an index of test performance. By utilizing the effect of adaptive testing on test scores as an index of test performance, we can evaluate the construct validity of the test scores. We can, in this way, be able to determine whether the test scores are valid and reliable. In this way, we can also determine whether the test scores are valid and reliable. We can then, in this way, be able to determine whether the test scores are valid and reliable. In this way, we can also determine whether the test scores are valid and reliable. We can then, in this way, be able to determine whether the test scores are valid and reliable. We can then, in this way, be able to determine whether the test scores are valid and reliable. We can then, in this way, be able to determine whether the test scores are valid and reliable. We can then, in this way, be able to determine whether the test scores are valid and reliable. We can then, in this way, be able to determine whether the test scores are valid and reliable. We can then, in this way, be able to determine whether the test scores are valid and reliable. We can then, in this way, be able to determine whether the test scores are valid and reliable. We can then, in this way, be able to determine whether the test scores are valid and reliable. We can then, in this way, be able to determine whether the test scores are valid and reliable. We can then, in this way, be able to determine whether the test scores are valid and reliable. We can then, in this way, be able to determine whether the test scores are valid and reliable. We can then, in this way, be able to determine whether the test scores are valid and reliable. We can then, in this way, be able to determine whether the test scores are valid and reliable. We can then, in this way, be able to determine whether the test scores are valid and reliable. We can then, in this way, be able to determine whether the test scores are valid and reliable.
These benefits should be in addition to the purely psychometric increase in accuracy due to the adaptive testing. In the present study, different adaptive testing procedures are differentially successful in maintaining test items at the appropriate difficulty level. The results of the present study suggest that different strategies result in differential reductions in these mean item difficulties.

This subset of studies includes a variety of designs which are currently being pursued. In one study, we are currently including the non-examining student who successfully perceives the difficulties of test items presented to them. If they cannot distinguish easy from difficult items, the characteristics of items of different difficulty will produce these different psychometric properties. The behavior exhibited by each group of students with directly comparing the tests of experimental and control groups will address this issue of test-taking motivation. This study is also concerned with the effects of feedback on the test-taking behavior of the same psychological variables that is, a subgroup of testees receive information after each item as to whether or not it was answered correctly. In a third study, we are studying the effects of adaptive testing on test-taking behavior. In this study, testees answer a multiple-choice test questions by assigning probabilities to each of the five alternatives, within the constraint that the five probabilities assigned sum to 1.00. By an analysis of the relationship of the testee's probabilities to the known difficulties of the items, we can determine the likelihood that an individual was guessing on a test item. This study currently involves the use of multiple-choice tests of guessing or controlling the computer's ability to evaluate test items on the basis of the testee's answer. These studies are intended to be used to derive a method for improving item selection and to assess the validity and reliability of the adaptive testing procedure.

In summary, the results of the present study suggest that adaptive testing procedures can be used to improve the accuracy of test scores for minority and non-minority groups. These procedures can be used to achieve the following objectives:

- Minimizing Testing Time
- Personalized selection and placement
- Accurate measurement of ability
- Efficient use of test items
- Reduction of test anxiety

Economic Advantages of Accurate Test Scores

However, the real economic advantages of computerized testing will derive from the greater accuracy of test scores. Since adaptive testing results in scores which are both more precise and more economical, the use of computerized testing will be economically advantageous. Furthermore, computerized adaptive testing will be more efficient and less costly than traditional testing methods. The use of computerized adaptive testing will also increase the validity and reliability of test scores. In addition, the use of computerized adaptive testing will improve the fairness of test scores, since it will provide a more accurate measurement of ability. Finally, the use of computerized adaptive testing will reduce the amount of time required for test administration, since it will allow for the simultaneous administration of multiple tests.

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COMPUTERS AND PEOPLE for July, 1976

HOARE—Continued from page 7

tion for his work. This is a most urgent topic of research at our universities and elsewhere, and it is to be hoped that the results will be most widely and most rapidly propagated.

Mastery of Tools

A final point of contrast lies in the working tools of the profession. An engineer naturally demands tools (or their effect on precision, reliability, convenience, and cheapness in use. In many professions, the tools are something subtle; in others they are something basic; in either case the engineer has developed an intuitive understanding and a sensitivity to the proper area; and this frees him to devote his whole intellectual effort to the understanding and solution of his client's problem.

The basic tools of the programmer are the programming languages, systems, compilers, interpreters, editors, debuggers, and other software supplied in profusion by the manufacturers of his computer. But what a sorry comparison with the tools of other professions! That they are ineffective, that they are prodigal of time and storage, that they are inconvenient in operation—these are facts that have long been recognized and widely suffered.

Complexity...

Perhaps the worst symptom (and also a large part of the cause of the trouble) is their extraordinary and growing complexity, which totally beg- gers the comprehension of both user and designer. Amateurs can only guess at what is going on, and what goes wrong, and why.

Misusing as Power...

But still we have some experienced programmers and managers who actually welcome the stuff, praise it, and go on working and learning. More perhaps the fatal attraction is the very complexity, which would result in the initial, not to mention the continuing, use of power and sophistication. They may have even less creditable motives: the use of inefficient tools both increases and excuses the unreliability of his programs; the use of inefficient tools both increases and excuses the inefficiency of his programmer; and inefficient tools can protect him from close scrutiny or control of his client or employer.

Resulting in Perpetuation...

And finally, after a few years experience of some particular program, the programmer finds that even his partial understanding of it can command a high salary, and he has the strongest motive for refusing to learn something new, and for rejecting the idea that it might possibly be an improvement. And from myself, this is the reason that people who have been in the computer field many years ago have an even stronger personal and financial interest in perpetuating the programs they are using.

A Discipline of Software Engineering

The attempt to build and discipline of software engineering as such should foundations must surely be decried, like trying to base chemical engineering on the chemical theories, the automation of the assortment of a flat earth. But the study of manu-
of intelligent systems. This is particularly important for developing systems that can operate in complex and uncertain environments. The field of machine learning focuses on developing algorithms that allow computers to learn from data and improve their performance over time. This is achieved through various techniques such as supervised learning, unsupervised learning, and reinforcement learning. The applications of machine learning are vast and include areas such as natural language processing, computer vision, robotics, and autonomous vehicles. The advancements in this field have led to significant improvements in the capabilities of artificial intelligence systems, enabling them to perform tasks that were previously beyond their reach.
Computing and Data Processing Newsletter

ADAPSO Publishes Survey on Sales, Property and Use Tax Laws As They Affect the Computer Industry in 55 States

J. L. Dwyer
Executive Vice President
ADAPSO
210 Seventh Avenue
Monmouth, NJ 07748

The Association of Data Processing Service Organizations (ADAPSO) has published a 50-State survey of personal property, sales tax, and use tax laws as they relate to computer service, data processing, and related facilities. The 15-page survey, a year in preparation, represents what ADAPSO believes is the only work of its kind in existence. The purpose of this survey, said Jerome L. Dwyer, executive vice president of ADAPSO, which represents time-sharing, data center, software rental, and facility management companies in the more than $5 billion computer services industry, is to summarize the impact of state sales, use and personal property tax laws on the computer industry at the present time. Mr. Dwyer also said that the survey is meant to serve as an industry reference guide for use by general management and accounting and legal staffs.

The three areas surveyed for each state, personal property, sales tax, and use tax, are summarized in the introduction to the survey:

1. **Personal Property Tax**

   The survey notes that, generally, tangible personal property and real property within the state are subject to taxation, although, occasionally, intangible personal property is also taxed. While some states impose a sales tax on personal property, the tax is almost always directed toward stocks, bonds, promissory notes, and the like, and therefore, has special applicability to the computer industry. In addition, hardware is considered tangible personal property in all jurisdictions, thus subject to the property tax.

2. **Use Tax**

   A use tax is levied in tangible personal property transactions and is imposed by the state, the sales tax imposed by that state has not been paid. This situation normally occurs where tangible personal property is bought from a corporation located in the state, where the sales tax imposed by that state has not been paid. Therefore, a provision is normally included in the state which allows the state to collect the sales tax on the purchase. The state of California, for example, has this provision. The sales tax paid is then imposed as the sales tax paid was included in the state's purchase or lease. The definition of sales, inventory and consumption usually includes rentals, leases, and services which are included unless otherwise noted.

3. **Sales Tax**

   The tax is levied on tangible personal property, and, in some states, on services. These services are designated specifically by the statute or are included in the definition of "sale" or "sales tax". The definition has obvious relevance to data processing.

The survey points out that in addition to taxes on tangible personal property, many states also impose sales tax on gross receipts derived from services performed within the state. These services are designated specifically by the statute or are included in the definition of "sale" or "sales tax". The definition has obvious relevance to data processing.
GAMES AND PUZZLES for Nimble Minds — and Computers

Neil MacDonald
Assistant Editor

It is fun to use one’s mind, and it is fun to use the artificial mind of a computer. We publish here a variety of puzzles and problems, related in some way to another computer game playing and computer puzzle solving, or to the programming of a computer to understand and use free and unconstrained natural language. We hope these puzzles will entertain and challenge the readers of Computers and People.

NAYMANDIJ

In this kind of puzzle any array of random or pseudorandom digits ("generated by Nature") has been subjected to a "definite systematic operation" ("chosen by Nature") and the problem ("which Max is faced with") is to find out what Nature’s operation was.

A "definite systematic operation" meets the following requirements: the operation must be performed on all the digits of a definite chain which can be designated; the result digits are a kind of evident, systematic, rational order and completely removes some kind of randomness; the operation must be expressible in more than four English words. (But Max can use more words to express it and still win.)

MAXMINDIJ

In this kind of puzzle, a maxin (common saying, proverb, some good advice, etc.) using 14 or fewer different letters is encrypted (using a simple substitution cipher) into the 10 decimal digits or equivalent signs for them. To compress any extra letters into the 10 digits, the encipherer may use puns, minor misspellings, equivalents like CS or K5 for X or vice versa, etc. But the spaces between words are kept.

NUMBLES

A "numble" is an arithmetical problem in which: digits have been replaced by capital letters; and there are two messages, one which can be read right away and a second one in the digit cipher. The problem is to solve for the digits. Each capital letter in the arithmetical problem stands for just one digit 0 to 9. A digit may be represented by more than one letter. The second message, which is expressed in numerical digits, is to be translated (using the same key) into letters so that it may be read; but the spelling uses puns, or delirious (but evident) mispellings, or is otherwise irregular, to discourage crytanalytic methods of deciphering.

We invite our readers to send us solutions. Usually the (or "a") solution is published in the next issue.

SOLUITIONS

NAYMANDIJ 766: Make columns 13 odd.
MAXMINDIJ 766: Do the best that you can.
NUMBLES 766: Oak is farmer’s from.


Completing the table:

<table>
<thead>
<tr>
<th>Task</th>
<th>Time Required</th>
<th>Charge (per hour)</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Software Development</td>
<td>200</td>
<td>Fixed Rate</td>
<td>$4,000</td>
</tr>
<tr>
<td>2. Modifications (Estimated)</td>
<td>20</td>
<td>$40 per hour</td>
<td>$800</td>
</tr>
<tr>
<td>3. Training</td>
<td>16</td>
<td>Included in development</td>
<td></td>
</tr>
<tr>
<td>4. Long-range Support</td>
<td>40</td>
<td>$30 per hour</td>
<td>$1,200</td>
</tr>
</tbody>
</table>

There may be a large difference between the quoted cost for development and the true cost.
COMPUTER GRAPHICS and ART
FIRST TWO ISSUES NOW PUBLISHED

Partial Table of Contents — Vol. 1, Nos. 1 and 2

Learning Through Graphics
by Dr. A. R. Hoare, University of California, Irvine, California
A new method for computer, education, and graphics
by a teaching authority.

Art of the Technological World
by O. Herbert Frankle, Munich, Germany
Computer art as the bridge between the two realms of
art and industry.

Extending the Graphic Compatibility System to Three Dimensions
by Robert F. Pohl, Purdue University, Lafayette, Indiana
Design considerations for a new-oriented 3D graphics system.

A Personal Philosophy of Ideas, New Hardware, and the Results
by Duane Pyle, University of Utah, Salt Lake City, Utah
The framework from Sams and Sutherland allows the
artist to treat the computer as a paint and brush medium.

How to Build Fuzzy Visual Symbols
by Alain Maurois, Honeywell Bull, Paris, France
A new approach to computer art and graphics for a
computer scientist.

The State of the Art of Computer Art
by Grace C. Harkins, Editor
Comparisons of early computer art and today's new art.

Inexpensive Graphics from a Storage Cathode Ray Tube
by Charles J. Friskee and Robert L. Morris, Tufts University,
New Orleans, Louisiana
Illustrations and photographic techniques used to achieve
graphics from a storage tube CRT.

An Investigation of Criteria for Evaluating Computer Art
by Thomas E. Under, Ohio State University, Columbus, Ohio
The new aesthetic of computer art requires a departure from
the previous, formalistic, traditional criteria for evaluating art.

COMPUTER GRAPHICS and ART is a new international quarterly of interdisciplinary graphics for graphic designers and
computer artists. This new periodical is aimed at students,
teachers, people from undergraduate and graduate institutions,
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Its topical coverage is broad, including a variety of fields.
It is useful, informative, entertaining, and current. Our goal
is excellence, and to achieve this objective, we invite our
readers to participate actively in the magazine, and to advance
the state of the art of computer graphics by communication,
sharing, and dissemination of ideas.

We invite you, your colleagues and students to help us
achieve this goal.

List of Coverage for Up-Coming Issues

Applied Arts and Graphics
Architectural Graphics
Computer Graphics
Computer-Generated Graphics
Computer-Generated Graphics in Physics, Chemistry, Mathematics, etc.
Computer Graphics for New Applications
Display Systems and Graphics
Fine Arts and Media Explorations
Graphics in Business
Graphics in Education
Graphics in Education
Interactive Graphics Language and Systems
Languages for Computer Graphics and Graphics Primitives
Software Systems and Graphic Requirements
Statistical Packages and General Graphics
Symbol for Computer Graphics Courses

THE WORLD'S LARGEST MOSQUITO

Computers and people
formerly Computers and Automation

July, 1976
Vol. 25, No. 7

The Engineering of Software
— C. A. R. Hoare

Universal Vendor Marking (UVM)
— William S. Anderson

Computers and Society: A Theme for a Course and a Final
Examination
— Edmund C. Berkeley

Software Consultants:
An Introduction
— Jack Cleggett

Computerized Adaptive Ability
Measurement
— David J. Weis

Computers and Society: Films —
An Inventory
— Lois A. White

The Berkeley Entomological Society

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5. I am interested in: ( ) books and wholly computer art reprints at low
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IV art manual. ( ) 46 page interdisciplinary graphics bibliography by G. Harkins

6. Additional Comments (attach another paper if needed):
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WHAT IS GENERALLY TRUE AND IMPORTANT =

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This field includes the systematic study of the prevention of mistakes.

MONEY is important —
The systematic prevention of mistakes in your organization might save 10 to 20% of its expenses per year.

“RIDE THE EAST WIND: Parables of Yesterday and Today”

by Edmund C. Berkeley, Author and Anthologist

Published by Quadrangle/The New York Times Book Co., 1974, 224 pp., $6.95

Missile Alarm from Grunelund

Once upon a time there were two very large and strong countries called Bazania and Vosnia. There were many great, important, and powerful leaders of Bazania who carefully observed an enormous fear of Vosnia. Over and over again these important and powerful leaders of Bazania would say to their fellow countrymen, "You can't trust the Vosenian. And in Vosnia there was a group of great, important, and powerful leaders who pointed out what dangerous military activities the Bazanians were carrying on, and how Vosnia had to be militarily strong to counteract them. The Bazanian leaders persuaded their countrymen to vote to give them enormous sums of money to construct something called the Ballistic Missile Early Warning System, and one of its stations was installed in a land called Grunelund far to the north of Bazania.

Now of course ballistic missiles with nuclear explosive can fly any kind of a path all over the world, and they do not have to fly over northern regions. But this kind of reasoning made no influence on the leaders of Bazania who wanted the money for building 150,000 stations. Did it have influence on their countrymen, who were always busy, trying to make money — in fact often too busy to think clearly.

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27 authors
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[C] — Editorial
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Ambiguity and Computers — II

Translation from one natural language to another has been largely given up by the computer programming profession. One of the standard reasons offered is ambiguity: natural language is ambiguous and so the computer cannot do as good a job as a human being. Another reason is that the human being has much knowledge and experience to draw on, of how words go together. Third, it is asserted that a straightforward translation by computer says basically so little that it is clear that a human being is always needed to correct it and make it sound like normal English — the operation of post-editing, etc.

Is this still a good argument? Or is it an argument that will be left high and dry on the beach as the tides flow in new directions?

Let's begin with an example. Let's choose a portion of the famous fable by La Fontaine, "The Crow and the Fox":

Maître Corbeau, sur un arbre perché,
Tégait en son bec un fromage;
Maître Renard, par l'odeur alléché,
Lui tint à peu près ce langage:
"Ah, bonjour, Monsieur du Corbeau,
Que vous êtes joli que vous me semblez beau ..."

English translation, word for word:

Master Crow on a tree perched
Held in his beak a cheese;
Master Fox, by the smell allured
To his held a little near this language:
"Oh, good morning, Sir of Crow,
How you are pretty! How you to me seem beautiful ..."

English, in a more normal idiom:

Master Crow perched on a tree
Held in his beak a piece of cheese;
Master Fox, drawn by the good smell,
Spoke to him, in about these words:
"Oh, good morning, Sir Crow,
How handsome you are! How beautiful you seem to me! ..."

The clarifying changes fall into two classes:

— Change of word order, as in changing "How you to me seem beautiful" into "How beautiful you seem to me"; and

— Disentangling of ambiguity and sharpening of meaning, as in: (1) assigning different translations to two occurrences of the same French verb "tenir," resulting in "held" for "tenait" and "spoke to" for "tint"; (2) changing "pretty" to "handsome," because in English a woman is pretty but a man is handsome, and changing "cheese" to "a piece of cheese," because in English cheese is a mass word like butter, but not in French; etc.

In limited contexts, which apply to any one passage of material to be translated, these operations of change of word order and sharpening of meaning are not difficult. Plain ordinary people talking in the common everyday world do it all the time. There is no substantial reason why a computer program cannot do these operations in limited contexts.

Another effort at computer translation from one natural language to another, in limited contexts, using 1976 ideas for dealing with ambiguity, should have useful and significant results.

Edmund C. Berkeley

Editor

COMPUTERS and PEOPLE for July, 1978