The Engineering of Software: A Startling Contradiction

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"The attempt to build a discipline of software engineering on such shoddy 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 the gladsome 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 recognise 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 signigicant cause of failure in software are 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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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 retailing 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 1966 — 10 years ago — and as an international data processing standard in 1969. However, its practical application at the point-of-service awaited advances in wand technology, which happily have now occurred.

The UVM program being launched currently is due to the efforts of those who saw the need for an industry-wide marking standard, and who then spearheaded the adoption of such a standard. Certainly we are all indebted to the foresight of the efforts of the Manufacturers Technical Advisory Committee of the Computer and Business Equipment Manufacturers Association; to the NRMA Systems Specifications Committee; to those merchandise 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 a way of forging the missing link — in a chain of recent hardware and software advances which can move retail 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 NRMA rather than by a single equipment manufacturer; hence, it is a standard which everyone can support.

— The 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/punch, bar codes, or magnetic codes.

— 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 proprietary systems for merchandise marking — now endorse a Universal Marking standard. In actual 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 capable of supporting different system approaches. The software problem is also simplified. And 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, however, that the first computers used in retailing were also expensive. Yet today anyone can buy essentially the same computing power as that provided by the original Univac I, in a desktop electronic calculator costing a few hundred dollars. Over the long run, new technology will be constantly shaving away at equipment costs. Add to this the favorable effect of increasing volume, as scanning becomes widespread, and the cost bugaboo begins to look rather innocuous.

Based on a talk at the annual convention of the National Retail Merchants Association, in New York, NY, January 1976.

These are a few of the reasons why the equipment manufacturer is willing to work with everybody and anybody to assist in the implementation of the Universal Vendor Marking standard. It seems to me that such a standard is equally 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 rather than 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 unit merchandise movement from the point-of-order to the point-of-service. 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 the computer, black 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, source marking will get incoming merchandise to the selling floor faster, by reducing the burden of store-level marking. This is a key consideration at a time 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. These include improved stock control, faster and more accurate filling 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 his stake in this program? I think his stake is important because UVM can mean new levels of shopping convenience, time saving, and greater protection against error. It should also result in a better selection of merchandise, by dramatically reducing out-of-stock situations.

The advantages of UVM as seen by the equipment manufacturer are real, and therefore our respective industries should not lack incentive in getting behind the UVM implementation program. But we should recognize that what has been 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 manufacturer, there is a need to acquire additional experience with the new NRMA standard by installing working systems in a variety of retail environments. NCR, for example, took its 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 involves 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, Levi Strauss & Co., will begin a vendor marking program for Foley's of Houston. Several other merchandise manufacturers will launch similar efforts in the near future. Thus, 1976 should put to rest any speculation that the new standard is 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 its future systems progress will want to get some first-hand experience with the UVM program. Starting such a program now, with a limited in-house marking operation, will provide valuable guidance for planning future systems. At the same time, it will produce immediate benefits in the form of additional merchandising information.

Implementation

Merchandise manufacturers now have a green light for planning, and beginning to implement the new marking standard. No doubt many vendors will seize this opportunity. Others will wait for someone else to take the lead. However, experience with comparable standardization programs — specifically the banking industry's Magnetic Ink Character Recognition Code and the food industry's Universal Product Code — has demonstrated that those who adopted a friendly, welcoming attitude towards standardization achieved an important competitive edge. In fact, this applies to all of us who have a stake in UVM — whether equipment manufacturer, retailer, or vendor.

Clearly, the success of any retail standardization program depends on vendor marking. In the implementation of Magnetic Ink Character Recognition, it was essential for the printing industry to enthusiastically support the new MICR standard. In the case of the Universal Product Code, again the primary printing responsibility has been borne by the food manufacturer. OCR-A is no different.

Implementing any new standard is of course a big and complex undertaking. This is especially true when the standard involves an industry with the tremendous diversity of retailing and its many thousands

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Computers and Society:
A Theme for a Course and a Final Examination

Edmund 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?"

Victor J. Farmer, formerly of "Computerworld" and now of American Used 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 adviser or consultant to a government commission. What should you know about the issues related to computers and society? 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 survived in business for 25 years, and has decided to "get started" in computer data processing. Mr. Jones, who is a friend of yours, says to you (knowing that you have a master's degree in computer science from B.U.):

> Come and 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. Ombudsman. The City of Vast Rapids, population 3/4 million, has many municipal information systems, both computerized and clerical. A vociferous local chapter of the League Against Computers and Technology appears to be significantly interfering with expansion of the computerized data processing systems.

The city council has decided to hire an ombudsman to reduce the acrimony. Prepare a good set of guidelines for the ombudsman, dealing with both information and recommended behavior.

3. Computers and Privacy. Much discussion, argument, and many important governmental decisions both in the United States and outside have occurred in the area of computers and privacy. State 15 of the more important points and happenings.

4. Symbiosis of Man and the Computer. President John Kemeny of Dartmouth, in his book "Man and the Computer," has argued a case for believing in the "living together" of man and the computer (as species each necessary to the other's survival). Outline his argument and assess its validity.

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 have hit very solid obstacles 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 for a report on "How can we use computers to best advantage in determining solutions to problems of limits to growth?" Outline your report, giving an adequate statement of facts that you refer to.

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

Is this good? Why? Is this not good? Why?

Here "good" is defined as "in the best interests of society, business, production, and scientific and technological advancement."

7. Hippocratic Oath for Engineers. Charles Susskind, in his book "Understanding Technology," proposes a Hippocratic oath for engineers similar to the Hippocratic oath administered to graduates of many modern schools of medecine.

How would you define a "computer professional"? How would you define an "information engineer"? Are there differences between them? If so, what would be the differences?

What are the 11 promises included in Susskind's proposed oath? What are the reasons in favor of these points? What are the reasons against?

8. Brains, Thinking, and Artificial Intelligence. Define the following terms: artificial intelligence; natural (i.e., nonartificial) intelligence; common sense; 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 features of the "computer brain."

Do you consider that artificial intelligence provided by computers can help substantially in solving the critical problems of survival of man on this planet? Why or why not?

9. Humanizing Information Systems. A recent conference in Canada (at Stanley House, Gaspé, in 1973) dealt in detail with features of information systems which would make them more humanized — less irritating and objectionable to human beings.

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

10. Education and Computers. What do you recommend as the 6 or 8 most effective uses of computers for improving education? Why these and not others?

11. Use of Computers for Criminal Purposes. What in brief was the story of the Equity Funding scandal? If in a computerized system that 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 criminal purposes.

12. Computers and Employment. There is a widespread fear that more and more white collar jobs (for clerks, lower level management, and middle management) 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 systems analysis and write computer programs were invented, and the process should displace 50 per cent of human programmers, what would be your recommendations for new employment for the displaced programmers?

The Rehn plan was adopted in Sweden to deal with technological unemployment. What is this plan? What are the reasons for believing that this plan would work well in the United States?

What are a dozen occupations for college graduates which would be very highly resistant to technological unemployment?

13. The Most Important Problems 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 ten thousand years? The criterion for inclusion of a problem in this class is that if the problem is not solved, human beings will become extinct.

You have become an adviser to a United Nations commission studying the applications of computers in this area. What would be your detailed recommendations as to the use of computers to define the problems and to compute solutions to these problems?

14. Computers and the War in Vietnam. So-called "modern" warfare, such as took place in Vietnam from 1965 to 1975, uses computers, and related electronic systems that 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 adviser to a military commission for the purpose of improving and extending the application of computers to warfare, what would be your response? Why?

15. Computers and the Home. What are 15 possible applications of small computers or computer terminals in homes?

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

16. Computers and Economic Planning. In "The New York Times Magazine" for January 25, 1976, there was a long article "The American Plan — National economic planning will arrive when businessmen demand it — and demand it they will, to save the capitalist system," written by Robert L. Heilbroner, a professor of economics at the New School for Social Research in New York. He says:

"America is drifting into economic planning. ... Senators Hubert Humphrey and Jacob Javits have joined forces to introduce a bill establishing a national planning agency. Eminent economists led by John Kenneth Galbraith and Nobel Prize winner Wassily Leontief have endorsed the bill. So have many labor leaders ... and a small but growing number of businessmen such as Felix Rohatyn of Lazard Frères and Henry Ford have spoken out for the establishment of some form of national planning.

"... A national economic plan will probably be a coordinated set of general economic targets, say: a 50 per cent reduction in unemployment; a reduction of the rate of inflation to 5 per cent; an expansion of the rate of economic growth to 6 per cent. ... National economic planning is an effort to coordinate existing plans ... as well as to extend the reach of our control over the economy.

"... In fact the big corporations in all industrial areas act like private planning agencies, a point eloquently expounded by Galbraith. To a very great degree, the big companies hold the market at bay, raising or lowering prices when they want to, not when an oceanic flood of competition forces them to. So too, they expand (or contract) their enterprises according to long range forecasts and ignore the immediate press of business conditions. ..."

You have been selected as a 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., left to pencil and paper, discussion by committees, etc. In other words, what would be useful applications of computers to economic planning? and what would be wasteful or injudicious applications? What kinds of data would you seek so that the computerized areas of national economic planning would produce reliable and significant results? □

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 — each needs instructions, called programs of software, to solve problems. The TOTAL COMPUTING SOLUTION 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:

- Computing Calculators vs. Computers
- Ease-of-Use
- Storage Capacity
- Support
- Training
- Available Software
- Costs
- Delivery Schedules
- Reliability
- Power and Air Conditioning
- Facility Preparation

Software

While most people think in terms of hardware, software is also vital for success. Good software can often 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 errors 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 programs 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 suit 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 form, you may be able to 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 or cannot easily modify one, custom software, written for you to satisfy your specific application, needs to be considered.

There are many different sources for custom software; the one to be chosen depends on the amount of custom software you'll need. Many organizations that use computers extensively employ a full-time programmer to write and maintain custom software. If your application software requirements are not so 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.

Based on a publication by Hewlett Packard, "An Introduction to Software and Consultants", and used with permission.

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.

- Independent Analysis of Your Problem — Many companies prefer an independent consultant to review their problems and 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.
- Multivendor Purchase — 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 and with integrating 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 make good management decisions?

The key to success is to understand and be able to express your needs. Your software consultant and/or your manufacturer's representative will meet with you to help you analyze your problem and make recommendations. However, to make effective management decisions, you should have some insight into how a computer and software can solve your problem. Very simply, your starting information (called input) is entered into the computer; the information is stored in its memory; computations are performed; and the results (called output) are printed. All these functions are controlled by the software.

It is important to determine the amount of information that must be stored and processed and exactly what must be done to it.

The first step in this process is to know what you really want. Try to describe your problem in as much detail as you can. If it is simple, a brief explanation will be sufficient; however, if it is complex involving many related tasks, list and describe each separately. If you have an idea of how you want your problem solved or if you know someone who has solved a similar problem, be sure to let your consultant know.

Your software consultant and/or your manufacturer's representative will have many questions about what you want to do and how you want to do it. They will be trying to analyze your problem and create the best hardware and software system for your needs. Size is a major consideration. Too large a system will be too expensive. Too small a system will not do your job efficiently. Basically, they will be interested in:

- Input Information and Source Documents — They'll want to prepare a list of all the data to be entered. For commercial applications, where source documents are available, they will ask you for samples or rough layouts.
- Storage Requirements — It is important to determine the amount of information that will have to be stored. A list of your information, its quantity, description, and use will be required.
- Computations — They will also want to determine exactly what calculations and data manipulation you require.
- Output and Results — 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. If you need a graph or printed table, make a rough or use 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 serves many purposes. In addition to avoiding potential problems, it helps to get your staff and your management involved. By asking for their inputs, you can dispel many fears.

Here are some suggestions for items to beware of when you review your plan.

- Potential Expansion — Estimate potential growth. If your present problem involves entering 2,000 items, will it grow to 3,000 or 5,000?
- Missing Data — Is it beneficial to have another report or some additional information?
- Do a Trial Run of Your Procedures — Once you have set up your forms and procedures, run through the entire process from beginning to end. Use rough forms, if possible, and see if your procedures do everything that you need.

Locating a Consultant

If you wish to use a consultant, investigate consultants that are available in your area. You may also want to ask some of your business associates if they know of any consultants that they would recommend. Your own trade association may have a list of people who consult or who have worked with consultants. There are some computer societies that might provide some leads, too:

- DPMA — Data Processing Managers' Association
- ACM — Association of Computing Machinery

Another good source is the telephone company's Yellow Pages; look under the headings:

- Data Systems — Consultants and Designers
- Automation Consultants
- Data Processing Services
- Engineering Consultants

The initial visit with the consultant is a time for both you and the consultant to learn more about each other. Here's some information that you will probably want to know.

- Bank Reference — Ask the consultant for the name and address of his bank.
- Facts about Business Stability — What are the long-range capabilities of the consultant? — Inquire about how long has he been in business? — How long has he been located in the area?

— Customer References — Ask the consultant to provide you with a client list or the names of at least two or three past customers of his that you can contact.

What to Look For

Checking the consultant's background and experience is simple and should require only a small amount of time. Here are some things you will want to review.

- Stable and Successful Business — A good consultant should have a good credit reference and a stable business. Send the consultant's bank reference to your own bank and ask for a credit reference. Also, check with Dun and Bradstreet, a local credit bureau, or the Better Business Bureau.
- Experience in Your Application — It's very important that the consultant has an understanding of your problem.
- Cost — Software costs can be a significant part of the cost for your total solution. Minor modifications to existing software can cost a few hundred dollars. Specific modules average one fourth to one third of the cost for hardware. A major system development can cost as much as the hardware. Get an estimate of the costs.
- References — The consultant's references are one of the best sources to gather information about the consultant.
  - What were the strengths and weaknesses of the software that the consultant developed?
  - Was long-range support desired? If so, did the consultant provide good support? Was it at an additional cost?
  - Has the consultant satisfied past specifications of his proposal and other commitments?
  - Was the software delivered on time? If not, why not?
  - Were changes made during development? What were the additional charges?
  - What type of user training was provided and was it an additional charge? Was it adequate?
  - Were the costs competitive?

Is it possible to visit customer sites to actually see the consultant's software in operation?

Requesting a Proposal

After evaluating potential consultants, consider if you want to choose one consultant or seek competitive bids. In either case, send out a request for proposal (RFP). Your RFP should specify all the information that you need. Briefly describe your problem and outline the solution you want. Invite the consultant to submit a written proposal and specify a due date (allow from two weeks to one month). Request that the following information be included:

- Software Description — A detail of each module down to the gross function level.
- Manpower and Personnel — Anticipated manpower requirements for development, training, and support. Resumes of consultant personnel who may be involved.
- Costs and Method of Payment — All charges, including development, modifications during development, training, and long-range support. Will each be charged on a fixed-cost or time-and-materials basis?
- Payment Schedule — A specific schedule.
- Time Schedule — A schedule for each module and periodic review meetings.
- Documentation — All documentation that will be provided and costs.
- Warranty — The length of time after installation that the software will be warranted against errors in programming.
- Training — The location, training schedule, and the costs, if any.
- Installation Support — All support that will be provided at the time of installation, and any costs.
- Long-Range Support — All long-range support, if it is on-site, and what additional costs are involved.
- Ownership of Software — Ownership and rights of both parties to the sale, use, and modification of the software.

The Consultant's Proposal

Typically the consultant's proposal is the basis for your contract. Ask the consultant to provide any additional information you want in writing before you sign an agreement. Changes or additions at a later date may result in additional charges.

Certain sections of the proposal may be unique to the software consulting industry.

- Costs and Method of Payment — Consultants either charge a fixed cost to do a specified job or for time and materials. Often consultants will charge a fixed rate for the development of the software and then an hourly rate for training and long-range support.
- Payment Schedule — Most consultants expect to be paid for their work as it is being developed. Some consultants may require part of the amount due after acceptance of the proposal, a portion after delivery of the software, and the balance after you are satisfied with the software. Another common schedule is simply monthly billing for a fraction of the total cost while the software is being developed.
- Software Ownership — There are many different options. The consultant may want to retain ownership of the software and license its use to you. He then has the ability to resell the software to other users. He may sell the software to you but reserve the right to resell it. Or he may simply give all rights and ownership to you. Which option is selected is a function of the software and your negotiations with the consultant.
- Signing the Contract — The agreement should specify exactly what software and services are to be provided, all costs including any possible add-on costs, method of payment, development schedule and time limits, penalties for nondelivery or incomplete development, and any other terms that you feel are important.
- Evaluating Proposals — In evaluating proposals, one of the most important factors will be cost. Due to the way consultants quote costs, the quoted cost may not be a good estimate of the actual cost. The following chart demonstrates a good technique to determine the true cost by estimating reasonable expenses for a given period, for example, a year:

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Computerized Adaptive Ability Measurement—Part 2

Dr. David J. Weiss
Professor of Psychology
University of Minnesota
Minneapolis, MN 55414

"Accuracy in measuring an individual's ability level can be reduced by the individual's behavior in the testing situation. Guessing, poor motivation, frustration, anxiety, 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 evaluating 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 implies greater accuracy of measurement and greater utility in making longitudinal predictions. The simulation studies which supplement 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 studies 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 stradaptive test strategy. As was indicated earlier, and illustrated in Figures 2 and 3 (see Computers and People, June 1976, pp. 17 and 18), stradaptive tests yield "consistency" 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 strata used by an individual before the termination criterion is met. Highly consistent individuals use few strata, and inconsistent testees encounter items at strata of widely differing difficulties.

The Relation of Consistency and Predictability

We hypothesized that consistency should be related to reliability. Thus, the more consistent individuals should be more predictable over time, and the less consistent individuals less predictable. To study this hypothesis, we administered a stradaptive test twice to a group of individuals; an interval of about six weeks separated the two administrations. Using their first test results, we determined each testee's consistency score and subdivided the total group into five subgroups ranging from very high consistency to very low consistency (N = 17 to N = 41 per group). With each group, we calculated the test-retest correlation (stability coefficient) for each of the ten methods of estimating ability with the stradaptive test.

The general pattern of results was in the predicted direction, although it varied for different methods of estimating ability and consistency. The clearest pattern emerged for Ability Score 1 using Consistency Score 11 (see Figures 2 and 3). For the total group of subjects (N = 170) the testing-retest reliability was .65. As consistency increased so did reliability. For the most consistent group, reliability was .94, while the intermediate consistency groups had reliabilities of .85, .84, and .77. For other methods of scoring ability on the stradaptive test, reliabilities for the most consistent group were as high as .98, 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 on a given 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 in measuring an individual's ability level can be reduced by the individual's behavior in the testing situation. Guessing, poor motivation, frustration, anxiety, boredom, and other psychological variables can add error to an individual's test scores, which will reduce the utility of those scores for practical decisions.

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

Reprinted with permission from *Naval Research Reviews*, November 1975, published by the Office of Naval Research, Arlington, VA. Part 1 of this article was published in *Computers and People*, June 1976, pp. 14-17, 25.

These benefits should be in addition to the purely psychometric increases in accuracy due to the adaptive testing procedure. Since different adaptive testing procedures are differentially successful in maintaining test items at the appropriate difficulty level, we are also studying whether these different strategies result in differential reductions in these extraneous variables.

This subset of studies includes a variety of designs which are currently being pursued. In one study, we are concerned with whether testees can accurately perceive the difficulties of test items presented to them. If they cannot distinguish easy from difficult items, then it is unlikely that items of different difficulty will produce these different psychological effects. A second study is concerned with directly comparing the effects of conventional and adaptive testing on test anxiety and test-taking motivation. This study is also concerned with the effects of "feedback" on test scores and on 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 guessing behavior. In this study, testees answer a multiple-choice test question 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, in conjunction with the testee's ability level, we can evaluate the likelihood that an individual was guessing on a test item. We can then compare the relative frequencies of guessing on conventional tests and on different adaptive strategies to determine whether adaptive testing does indeed reduce guessing behavior. Within this study we are also evaluating the more general utility of probabilistic responding as an important alternative to the conventional binary response mode. Combined with adaptive testing procedures, probabilistic responding may result in a very powerful approach to ability measurement.

Our concern with the psychological effects of adaptive testing is motivated partly by the problems raised in the use of ability tests with minority persons. We are concerned with increasing the accuracy of measurement for minority individuals and thereby increasing the fairness of testing for these groups. Consequently, we are striving to identify those psychological variables which are more likely to operate to reduce the accuracy of test scores in both minority and nonminority groups, and to eliminate them from the testing situation insofar as is possible.

Three Defining and Restrictive Characteristics

Research in computerized testing to date has had three defining characteristics. First, it has assumed the existence of an unidimensional trait. That is, it is assumed that a given test item pool measures only one ability. A second characteristic of this research is that it is based entirely on between-item branching strategies. In other words, a testee's response to a given test item (or sequence of test items) is used to determine which item is to be administered next. Finally, the majority of adaptive testing research has used verbal test items, primarily because of the prohibitive expense of computerized display of pictorial materials.

Our future research in adaptive testing will concentrate on eliminating these three restrictive aspects of most current research. We will be concerned with developing branching models which do not require the restrictive assumption of unidimensionality. The unidimensionality assumption is unrealistic for several reasons. First, it is extremely difficult to obtain test item pools within any given ability domain (e.g., vocabulary or word knowledge) which are strictly unidimensional. This is due to the fact that dimensionality is partly a function of the difficulty of the test items; very difficult test items will tend to define different factors of ability than will moderately difficult or easy items. Secondly, even though a test item pool can be shown to be reasonably unidimensional (e.g., McBride and Weiss, 1974), such apparent unidimensionality is defined on the basis of the average characteristics of a group, the group of testees on whom dimensionality is studied. However, unidimensionality of a set of items for a group is no guarantee that the set of items will be unidimensional for an individual. Elsewhere (Weiss, 1973, pp. 39-42) I have shown some preliminary results which imply that different individuals are differentially scalable on an apparently unidimensional set of items. Our future research in this area will be concerned with systematically replicating and extending these results. If the phenomenon is verified, we will develop models which take intraindividual dimensionality into account in the interactive adaptive testing process.

Minimizing Testing Time

Personnel selection and placement is rarely successful when it is based on predictions made from measuring only one variable. Consequently, multiple-ability batteries have been developed which are used to assess the capabilities of individuals on a variety of occupationally relevant abilities. Even when these abilities are unidimensional, they are often correlated with each other. Using a strictly unidimensional branching model, adaptive testing would proceed by locating an individual's ability level on one variable, then proceed to another, and then to a third ability, and so on. But when abilities are correlated, this procedure wastes testing time since knowledge of status on one ability yields information relevant to an individual's status on other ability dimensions.

To minimize testing time, there are two ways to proceed. First, we can begin by assessing an individual's position on one ability. Then, using our knowledge of the correlation of that ability with a second, we can generate an initial ability estimate for testing on the second ability. To estimate a score on the third ability, we could use the multiple correlation of the third ability with the first and second to reduce the range of initial ability estimates for the third ability, and so on through all abilities. A second approach would be to conceptualize the correlated set of abilities as a multidimensional space and develop adaptive testing procedures to systematically branch an individual through this space. Thus, in a minimum set of items we would locate the testee's position on all abilities simultaneously. This latter model would be advantageous in that it could also be designed to simultaneously handle the problem of intraindividual dimensionality.

Testing Reasoning Ability and Memory

Our future plans also include the development of computer-administered tests to measure abilities not now measurable with conventional paper-and-pencil tests. These would include tests of reasoning ability, based on intraitem branching techniques. In these tests, the typical test item might be a problem situation, and the individual would be given a choice of a variety of sorts of information which he can appy to the solution of the problem. His choice of a given type of information will lead him by a successive series of further choices down a particular path of reasoning used in the solution of the problem. Some paths might lead to inappropriate solutions, and some to inefficient solutions. Thus, this kind of test item could be thought of as a "conceptual maze," where the quality of an individual's reasoning is determined by the nature of his process in reaching the solution, including its efficiency and the amount of time spent in making each decision. Tests of this kind, administerable to large numbers of testees only under computer control, should have important uses in personnel evaluation.

We also plan to develop tests of short-term and long-term memory in auditory, pictorial, and verbal modalities. The precise control which the computer provides in the measurement process will enable the measurement of these new abilities. When appropriate computer terminal equipment is available, we will also explore the utility of pictorial and spoken language tests to replace current printed verbal tests. Spoken language tests might supplement printed verbal tests for minority group members. Nonverbal tests might permit the adaptive measurement of abilities such as chart and map reading and visual scanning and interpretation to supplement currently available ability measures.

A Note on Costs

A discussion of computerized testing would not be complete without considering the economic feasibility of this mode of testing. The economic practicality can be viewed from two complementary vantage points: (1) the differences in actual costs of test administration, scoring, and reporting, and (2) the savings resulting from the characteristics of the test scores.

A major characteristic of adaptive testing is that it can considerably reduce the amount of time a testee spends on taking tests. Some adaptivete testing strategies can achieve with 30 items the validity and reliability of a 100-item conventional test. Thus, the average adaptive test need be only 10 minutes long compared to the 30 minutes required for a conventional test. Since the testee's time often represents both an individual and institutional investment, this two-thirds reduction in time should represent an important economic gain. If the testee's time is "free," i.e., no monetary savings are determinable from reducing testing time, there is still an economic gain possible since the time saved by the adaptive testing procedure can be used to measure the testee's abilities in other areas. In this way, adaptive testing could make accurate prediction of complex criteria possible without requiring inordinate amounts of testing time on the part of each testee.

Hidden Costs

Very little data is available on the actual cost of either adaptive testing or current paper-and-pencil procedures. In computing the costs of paper-and-pencil testing, a number of hidden costs must be kept in mind. These include costs of obtaining publisher's catalogues, ordering supplies, storing supplies, reordering, mailing answer sheets for scoring, keeping records of answer sheets submitted for scoring, and the like. These costs are, of course, in addition to the costs of purchasing test booklets, answer sheets, and scoring services (or hand-scoring keys and wages of scoring personnel). To this must also be added costs associated with waiting — waiting for supplies to arrive, for testees to congregate for testing, and for the test results to be scored. On the other hand, in computerized testing the test will be available at the push of a button or two. There will be no delays for score reports, no materials to order, no inventories to maintain. The test will be available when it is needed, and results (interpreted in a variety of ways) will be available instantly to assist in decision making.

Waters (1975) gives data estimating the costs of a computerized stradaptive test at 87¢ per testee, excluding development costs and costs of terminal equipment. Our calculations, again excluding development costs but including terminal equipment, range from $1 to $1.25 per test. Consequently, in one hour of testing time, a testee could complete six tests at a total cost between $6 and $7.25. Given the decreases in the cost of computers that have occurred in the last five years, and projecting them a few more years into the future, the direct costs of computerized testing will, in the near future, be less than those of paper-and-pencil testing.

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 accurate, adaptive test scores should result in fewer errors in selection, placement, and classification. Since training one man for one assignment may cost many thousands of dollars, each inappropriate assignment based on unreliable or invalid test scores can waste those thousands of dollars. An overestimate of a person's ability can lead to an inappropriate personnel assignment which can result in a waste of many additional thousands of dollars if the individual is not competent in his assignment. Conversely, an individual whose test scores are lower than his actual ability is underutilized. In this case the potential productivity of an individual whose skills and abilities are underestimated by poor testing procedures is lost, again costing money to the employing organization. Finally, the underutilized individual might be a retention or morale problem. In that case, the costs involved in training the individual are not fully recovered since his tenure (or performance) on the job will likely not be optimal.

Computerized adaptive testing does appear to be economically feasible. To the extent that it will give us tests which measure more accurately and span a wider range of occupationally relevant abilities, it should yield a substantial economic benefit for the military services. The search for the most practical and efficient way to implement adaptive testing procedures is just beginning. Our research results should provide the necessary data from which effective computerized adaptive testing systems can be developed and applied in the near future.

References

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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 of his tools the highest quality and precision, reliability, convenience, and cheapness in use. In many professions, the tools are quite simple; in others they are more complex. But in either case the engineer has developed an intuitive understanding and ingrained mastery of their proper uses; and this frees him to devote his whole intellectual effort to the understanding and solution of his clients' problems.

The basic tools of the programmer are the programming languages and compilers, job control languages and operating systems, utilities and other software supplied in profusion by the manufacturer of his computer. But what a sorry comparison with the tools of other professions! That they are unreliable, that they are profligate of computer time and storage, that they are inconvenient in operation — these are facts that have been long recognized and widely suffered.

Complexity . . .

Perhaps the worst symptom (and also a large part of the cause of the trouble) is their extraordinary and still increasing complexity, which totally beggars the comprehension of both user and designer. Among manufacturers' software one can find what must be the worst engineered products of the computer age. No wonder it was given away free — and a very expensive gift it was, to the recipient!

Masquerading as Power . . .

But still we have some experienced programmers and managers who actually welcome the stuff, praise it, want more of it, and even pay for it. Here perhaps the fatal attraction is the very complexity, which would revolt the instincts of any engineer, but which, to the clever programmer, masquerades as power and sophistication. He may have even less creditable motives: the use of unreliable tools both increases and excuses the unreliability of his programs; the use of inefficient tools both increases and excuses the inefficiency of his programs; and the complexity of his 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 product, 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 his manager who committed himself to that product many years ago has an even stronger personal and financial interest in its perpetuation.

A Discipline of Software Engineering

The attempt to build a discipline of software engineering on such shoddy foundations must surely be doomed, like trying to base chemical engineering on the phlogiston theory, or astronomy on the assumption of a flat earth. But the study of manufacturers' software is an excellent way to sharpen our understanding of the principles of software engineering, both because of its consistent violation of those principles, and because it makes a serious and creditable attempt to define the working tools of the software engineer.

It is important to take an optimistic, practical and forwardlooking approach. There are many ways in which existing tools can be used more effectively — by adoption of supplementary software packages, by instrumentation and tuning, by program editors and preprocessors, by structured programming aids, training manuals and courses, and by standards of programming practice. It is desirable to survey the range of methods which are immediately available for practical use, and to look slightly further ahead, and describe some of the possibilities of further improvement that are now being opened up by fundamental and applied research. Even if the practical difficulties of change delay the widespread application of results of new research, it is important that programmers and managers should understand now what they are; so that they are never again led astray by the specious promise of sophistication and complexity.

Evidence?

In this short sermon on the theme of software engineering, I have made many allegations against the quality of software, and against the competence, intelligence, and integrity of programmers. But I have not given a single example to support my case, nor have I named a single name. Let me do so now: I name the guilty man: I name myself. Within myself I have discovered all the faults which I have ascribed to programmers in general. If my remarks carry any conviction, it can only be because my reader has made a similar discovery. □

Weiss — *Continued from page 17*

F. M. Lord and M. R. Novick, Statistical Theories of Mental Test Scores. Reading, Mass.: Addison-Wesley, 1968.

J. R. McBride and D. J. Weiss, "A Word Knowledge Item Pool for Adaptive Ability Measurement." Research Report 74-1, Psychometric Methods Program, Department of Psychology, University of Minnesota, 1974. (AD 781894)

B. K. Waters, "An Empirical Investigation of Weiss' Stradaptive Testing Model." Paper presented at the Conference of Computerized Adaptive Testing. Washington, D. C., June 13-14, 1975.

D. J. Weiss, "The Stratified Adaptive Computerized Ability Test." Research Report 73-3, Psychometric Methods Program, Department of Psychology, University of Minnesota, 1973. (AD 768376)

D. J. Weiss, "Strategies of Adaptive Ability Measurement." Research Report 74-5, Psychometric Methods Program, Department of Psychology, University of Minnesota, 1974. (AD A004270) □

Anderson — *Continued from page 9*

of suppliers. We cannot expect overnight miracles. Nor can any single organization, or single industry do the job by itself. It will be a tough, painstaking and sometimes frustrating process. Above all else, it will demand enthusiasm, close cooperation, and teamwork.

There will never be a better time than now to get this program moving forward. □

Computers and Society: Films — An Inventory

Lois A. White
c/o The Society of Data Educators
983 Fairmeadow Road
Memphis, TN 38117

Editorial Note: Recently "Computers and People" received a "Data Processing Film Catalog" put together for the Society of Data Educators by Lois White. There are essentially two classes of films listed: technical films, providing explanations of computers, programming, operating systems, data processing occupations, etc.; and nontechnical films, dealing with the relations of computers to people, to society, to human concerns, etc. The following is an inventory of some fifty films belonging to the second class, drawn from that catalog. It is reprinted with permission of the Society of Data Educators and Lois White.

AMVER-AUTOMATED MERCHANT VESSEL REPORTS
A graphic fast-moving description of the AMVER system and how it works as an aid to the development and coordination of Search and Rescue efforts at sea. The system is shown in action as its electronic computers furnish positions and medical capability information of nearby merchant vessels in three distress cases — two different ships and one aircraft.
1965 color/sound free rental 14 minutes
United States Coast Guard Films

ANALOG COMPUTER
Demonstrations and solutions on the computer and other machines. Lecture by Dr. Wilfred Kaplan, professor of mathematics at the University of Michigan. The analog computer and its relationship to differential equations. (Mich)
1963 rental $6.25 28 minutes
University of Michigan

AT HOME, 2001 (THE 21ST CENTURY SERIES)
Uses model homes, animation, and live-action photography to consider some of the possibilities for the household of the future in terms of technology and changed patterns of urban living. Depicts a home in which the family lives in a light- and temperature-controlled environment, handling business and marketing by TV telephone in a computerized den, using a wall-size 3D television for entertainment and instruction, inflatable furniture, micro-wave cooking facilities, and robots for household chores.
1967 color rental $10.60 24 minutes
University of Illinois

AUTOMATION: THE NEXT REVOLUTION
Dramatizes the impact of automation on workers as production increases and the number of manufacturing jobs decreases. Points out that machines are rapidly becoming competitors with humans, rather than their servants. Men who create and use automated equipment say that although they are concerned for workers replaced by machines, the keen competition requires the use of machines wherever they cut costs. Shows industries radically affected by automation, and raises questions concerning the nature of "work." Stresses the importance of education and a more equitable distribution of the nation's wealth.
1963 black/white rental $7.10 29 minutes
University of Illinois

AUTOMATION: WHAT IT IS AND WHAT IT DOES
Explores the meaning and levels of automation from an electric can opener to transfer machines in an assembly line, to the more sophisticated feedback of a computer-controlled petroleum refinery. Encourages students to consider the implications of automation for their own future and to get the best possible general education.
1965 color rental $6.20 14 minutes
University of Illinois

BY THE NUMBERS
Story of image processing: how visual images are processed into numbers so that they can be interpreted by computers; the application of converting aerial photographs into detailed maps by using this technology. (IBM)
Color rental $1.50 16 minutes
University of Michigan

CAI IN NEW YORK
Depicts the operation of computer-assisted instruction (CAI) program in New York City schools, where computers are used for drilling, reviewing, grading, etc. Reactions from both students and teachers are discussed.
Color/sound rental $5 17 minutes
Purdue University

CAREERS IN COMPUTERS AND DATA PROCESSING
Produced for the Automation Institutes of America, this film explores the constantly growing needs of, as well as the variety of opportunities open in, science, business and industry for trained computer personnel. Further answered is the question of how today's young man or woman enters into this chal-

lenging computer field.
Color/sound free rental 15 minutes
Control Data

CLINICAL USES OF THE COMPUTER
Illustration and discussion of the 3300 computer and MED LAB time-sharing system in the pioneering biomedical application at Latter Day Saints Hospital, Salt Lake City, Utah. Explains how the digital computer is used in conjunction with analog equipment for diagnosis and treatment of disease and for monitoring postoperative condition of patients. Remote oscilloscope display stations are located in five different hospitals in the community.
Color/sound free rental 20 minutes
Control Data

COMPUTER ANIMATION
Discusses how, as animated films have become indispensable tools for educational and training purposes, the role of computers in their production has steadily increased. Shows and discusses animations generated by both analog and digital computers for weather displays, architectural and engineering stress analysis, and aircraft navigation and landing instruction, and also as works of art.
1970 rental $23 purchase $360 30 minutes
University of California

THE COMPUTER REVOLUTION
Presents an introduction to the new world of computers, emphasizing their present uses and their potential for the future. Explains that the computer is a machine that takes in coded information, stores it, organizes and mathematically processes it according to a program it has been given, and finally supplies the resulting information in the desired form. Points out that computers free men from tedious repetitive work.
1968 color/sound rental $7.90 3 minutes
University of Minnesota

COMPUTER SKETCHPAD
Discusses a new computer-programming system developed at M.I.T. which permits a man to communicate with a computer by drawing sketches on an oscilloscope. Shows how this system is used in designing and in developing flow charts. Discusses practical applications of the system in industry and research.
1965 black/white purchase $165 rental $9.50
29 minutes Indiana University

COMPUTERS: CHALLENGING MAN'S SUPREMACY
Writer Arthur C. Clarke and several computer experts optimistically appraise future developments and uses of computers. Clarke conjectures that by the year 2000 the computer will have surpassed the capacity of the human mind in some way, but that it will free man of many of his limitations and will help in the development of new types of consciousness.
1972 color rental $25 22 minutes
University of California

COMPUTERS AND HUMAN BEHAVIOR
Explores some of the research being conducted at the Carnegie Institute of Technology with electronic digital computers in an effort to evolve new theories about human mental processes. Dr. Bert Green, professor of psychology, demonstrates his computer experiments with perception of motion and depth. Dr. Herbert Simon with the help of the computer presents his theory of how human beings memorize. And Dr. Allen Newell shows how the computer was responsible for creating a new theory about human problem solving.
1962 black/white/sound purchase $165 rental $9.50
30 minutes Indiana University

COMPUTERS AND YOU
Explains and demonstrates in easily understood language the principles and uses, advantages and limitations, of computers. Examples of complex applications include a simulated moon landing.
1972 color rental $6.40 15 minutes
University of Illinois

COMPUTERS AT WORK
Views the computer under actual working conditions helping to produce toys; improving instruction techniques in schools; helping to launch spaceships; preparing better-tasting cake mixes; and helping make more efficient use of lumber. On-location filming offers the kind of realism that is so important in emphasizing computer studies and relating those studies to work. That realism is heightened by recorded comments of the very people who use the computer. (G.E.)
Color rental $9.50 12 minutes
Business Education Films
Available for purchase from General Electric for $145

THE CONTROL REVOLUTION
Uses animation to show the basic elements in a modern, continuous, self-adjusting control system. Uses a thermostat to illustrate feedback, and discusses control systems built around a computer. Shows computers in use in inventory, payroll accounting, and controlling and operating delicate machine parts in a factory. Also pictures process control at an oil refinery and the use of computers in the Social Security Administration. Guests comment on the release of management from routine decision making.
1962 black/white rental $6.40 30 minutes
University of Illinois

CONTROLLER-COMPUTER PARTNERSHIP
One of the first orders of business at FAA is to apply American computer technology to the heart of the aviation system, permitting controllers to spend their time making vital flight decisions, with computers performing the routine clerical chores. In laymen's terms, this film explains the emergence of a semi-automated air traffic control environment.
1969 color purchase $26 free rental 7.5 minutes
U.S. Department of Transportation

DEFINING SYSTEMS OBJECTIVES
A medieval case study provides a dynamic format for defining the objectives of a problem, the first step in a systems approach. The case study depicts how to identify the objective's intent, presenting alternative objectives, stating expectations, and measuring effectiveness.
Color/sound Super-8MM Cartridge $130 16MM Reel $155 10 minutes
McGraw-Hill Book Company

DISCOVERING ELECTRONIC MUSIC
The physical basis of music and how it can be created and altered by electronic means. The sound synthesizer and its capacity to create, envelope and filter sounds, imitate musical instruments, alter sounds of a jazz group and function as a musical instrument itself. Computer-controlled and computer-created music.
1970 color rental $9.20 23 minutes
University of Michigan

EARLY WARNING
The Veterans Administration Hospital in Minneapolis, Minnesota has one of the most extensive computerized patient-monitoring setups in the nation. A Control Data 3300 computer, by performing separate functions simultaneously, is assisting the V. A. Hospital staff in saving lives. While the computer is analyzing monitored data from patients in the intensive care ward, it is also continually calculating, during surgery, the patient's cardiac output and other vital information.
Color/sound free rental 25 minutes
Control Data

ENGINE AT THE DOOR
J. Presper Eckert, co-inventor of ENIAC and Vice President of the UNIVAC division of the Sperry Rand Corporation, discusses the question "Will machines ever run man?" Dr. Ernest Nagel, professor of philosophy at Columbia University, and Dr. C. R. DeCarlo, Director of Education for IBM, discusses the uses man makes of science and technology today and points out that wise and beneficial use of science and the instruments of technology is man's responsibility alone. Concludes that, although the computer is the machine most like man himself, it is the man not the machine who determines what is to be done.
1963 black/white purchase $165 rental $9.50
29 minutes
Indiana University

EXPERIMENT: WEATHER BY NUMBERS
Presents the story of Dr. Joseph Smagorinsky and his colleagues at the Environmental Science Services Administration and their experiments with mathematical equations and computers for predicting the weather.
1966 color rental $8.75 29 minutes
University of Illinois

EYES FOR COMPUTERS
Computers that "see" are already performing simple tasks in laboratory settings. At General Motors, computer scientists seek to learn whether computer vision technology can be extended to the production line. This film covers the basic principles of computer vision and the pioneering efforts of computer vision researchers. It also shows an experimental GM camera-computer-manipulator system for mounting wheels on hubs.
1974 color free rental 7 minutes
General Motors Motion Pictures

A FEW ESSENTIALS
This film traces the development of five essential areas of living: food, clothing, shelter, transportation and communications. Man's historical involvement with these areas is explored, as well as the role of the computer in helping manage the complex challenges of today's "essential" problems. Animation and live-action footage shot on location around the world.
Color free rental 16 minutes
IBM

INCREDIBLE MACHINE
Research in computer graphics at Bell Telephone laboratories; use of special computers to experimentally synthesize speech, make movies, compose music and to design prototype devices.
1968 color rental $4.50 15 minutes
University of Michigan

THE INFORMATION MACHINE
An amusing, clear account of the development of the electronic computer, beginning with primitive man's first efforts to solve his problems through the advent of machine simulation. Colorful and imaginative, this animated film is an effective method of explaining the nature of data processing.
Color free rental 10 minutes
IBM

"LINC" WITH TOMORROW
Demonstrates the use of a computer to obtain information from a patient concerning his medical history. The information obtained is combined with data from the physical examination by the physician and from laboratory analyses and stored in the computer. This combined information is available to the physician. Most patients enjoy using the computer and the physicians have more time for personal contact after data collection. Statistical analyses of laboratory tests not possible before and computer applications in psychosomatic medicine are also discussed.
1967 black/white purchase $165 rental $9.50
30 minutes
Indiana University

LOGIC BY MACHINE
Presents an introduction to computers. Discusses the computer revolution, the relationship between man and machine, and the relationship of the symbolic world of mathematics to the real world of objects and events. Explains how the computer can process millions of bits of data in seconds and can handle as many arithmetic figures in one minute as man can handle in a lifetime.
1962 black/white rental $6.40 30 minutes
University of Illinois

MANAGERS AND MODELS
Explores the design and simulation capacities of the modern digital computer. Shows how mathematical models and computers are used in the design and testing of the booster stage of the Saturn rocket. Discusses and illustrates how a computer is used to select the optimum design for a chemical plant. Follows step by step the mathematical simulation of the sugar refining process in an actual plant.
1962 black/white rental $6.40 30 minutes
University of Illinois

MARK OF MAN
Film traces the history of man's efforts to record information from the marks made on walls of caves, through the development of mechanical printing devices to high speed recording of computer data by cathode ray tube. Various applications of output from the SC4020 Computer Recorder, including pert charts, weather maps, missile trajectories, satellite orbits, and tool patch drawings.
Color/sound rental 13 minutes
National Microfilm Association

THE MARVELOUS CALCULATOR
This film traces the history of the computer, beginning with its earliest known origin and continuing to the present day. Two Minnesota television personalities, a man and a woman, narrate this film which was produced by Control Data Educational Institutes.
Color/sound free rental 19 minutes
Control Data

A MATTER OF SURVIVAL
Dramatizes the predicament of white-collar workers in the automated world of industry by portraying a situation in a company where computer methods are being introduced to take over much of the paper work, and, as a consequence, relieving a number of responsible, longtime employees of their jobs. Examines viewpoints of both management and employees, but offers no solution to the automation dilemma.
1969 color rental $11.25 31 minutes
University of Illinois

MOVIES FROM COMPUTERS: AN INTERIM REPORT
Demonstration of computer animation of films as a basic tool for learning.
1967 rental $4.75 20 minutes
University of Michigan

OF MEN AND MACHINES
Investigates the psychology of the man-machine relationship through the work of Dr. Paul Fitts, of the University of Michigan, Dr. Julian Christiansen, of the Wright Air Development Center, and Dr. George Briggs, of Ohio State University. Shows some of the ways in which man handles and processes information, the problems and dynamics of information feedback between man and machines, the human beings' behavior in highly complex man-machine systems, and the way in which information gained from these procedures has led to the redesign of equipment to fit human capabilities.
1963 black/white rental $6.90 29 minutes
University of Illinois

PERMUTATIONS
A computer graphics film with pulsing, hypnotic shapes and rhythms using graphics in motion to achieve different effects as with a language. Dots become analogous to letters of an alphabet; circles of dots to actual words; and formations of circles to sentence structures. The idea of permutation expressed in terms of moving imagery produced by computer art.
1970 color rental $4.50 7 minutes
University of Michigan

ROBIE HOUSE
An analysis of one of Frank Lloyd Wright's prairie masterpieces, the Robie House in Chicago. Includes pioneering use of computer graphics.
1972 color rental $3.90 13 minutes
University of Michigan

SCIENCE PROJECT
Adventures of boy with his first science project, building a simple computer. The project was successful because of thorough research in the planning stages. A report submitted to the science teacher explains the materials used, project objectives, and conclusions.
1960 color rental $5.40 14 minutes
University of Michigan

THE SECONDARY SCHOOLS AND COMPUTERS
Fred Gruenberger addresses a message to secondary school mathematics teachers (a recording of his speech of April 7, 1961, to the National Council of Teachers of Mathematics). Using an IBM 1620 computer in action, he shows some of the things which a computer can do in a high school. Traditional work is demonstrated by the solution of a system of four simultaneous linear equations. Advanced work is represented by a problem from differential calculus and by a problem in Diophantine equations. The Diophantine problem is also used to show how real research can be brought down to the high school level when a computer is available. Finally, by calculating some prime numbers and by displaying some very large factorials, it is shown how a computer can provide some amusing sidelights to the world of mathematics.
1961 black/white/sound 20 minutes
The Rand Corporation

SUBJECT TO CHANGE
Film describes in detail the operation of the payment center by the use of computers and microfilm at the Social Security Administration Headquarters, Baltimore, Maryland. Explains how the Master Beneficiary Record is maintained on microfilm and how individual payments are initiated or stopped. Discusses and demonstrates the updating process of records.
1968 color/sound rental 25 minutes
National Microfilm Association

THINKING MACHINE
Can machines think? How machines now solve specific problems may soon have "thinking" ability. How computers work; recent experiments in human versus machine behavior; visual perception. Computer wins checker game and writes a plan.
1960 rental $9 54 minutes
University of Michigan

"THINKING" MACHINES
Presents examples of recently developed machines which can perform in ways that resemble thinking in various degrees. Includes a mechanical mouse which learns to run an electronic maze, a digital computer which plays chess, and a pattern recognizer which may be the forerunner for systems which read handwriting or recognize individual human faces. Compares transistors with neurons to point out the wide gap which still exists between computers and the human brain.
1960 color rental $5.50 19 minutes
University of Illinois

THE UNIVERSAL MACHINE
Explains that the computer is a "universal machine" in that it is capable of doing whatever man is capable of instructing it to do. Comments on the incredible speeds at which the computer works and how decisions from a computer depend on the data and instructions put into the machine. Discusses the problem of a universal "machine language" — that is, agreeing on a single set of symbols and abstractions to define problems. Concludes with a discussion of the endless possibilities of using these mathematical machines.
1962 black/white rental $6.40 30 minutes
University of Illinois

UNIVERSE OF NUMBERS
Discusses the history of computer development from the first mechanical calculator invented by Blaise Pascal in the seventeenth century to ENIAC, the first completely electronic calculator built in the mid-1940's by John Mauchly and J. Presper Eckert. Mr. Eckert describes the actual construction of the mathematical machine. Explains, in lay terms, how a computer solves a problem. Tells how young people are trained in complicated computer technology.
1962 black/white rental $6.40 30 minutes
University of Illinois

WHAT IS AUTOMATION?
Describes automation as a series of automatic machines — one taking over where the other leaves off. Points out that automation has increased production ability and leisure time. A few skilled workers supervise the machines and check the quality of the product. Says that the demand for their types of skills will increase as more and more production becomes automated.
1965 color rental $5.90 14 minutes
University of Illinois

WHAT IS A COMPUTER?
Animated cartoon treatment which introduces the basic principles of the operation of a computer system. How a computer stores information, processes input data, and prints out responses. Demonstrates a flow chart and diagrams logic circuits

(please turn to page 26)

Computing and Data Processing Newsletter

ADAPSO PUBLISHES SURVEY ON SALES, PROPERTY AND USE TAX LAWS AS THEY AFFECT THE COMPUTER INDUSTRY IN 50 STATES

J. L. Dreyer
Executive Vice President
ADAPSO
210 Summit Avenue
Montvale, NJ 07645

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 software, data processing, and related transactions. The 156-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. Dreyer, executive vice president of ADAPSO, which represents time-sharing, data center, software and facility management companies in the more than $4 billion computer services industry, is to summarize the impact of state retail sales, use and personal property tax laws on the computer industry at the present time. Mr. Dreyer 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 state tax on intangibles, such tax is almost always directed toward stocks, bonds, promissory notes, and the like, and therefore, has no special applicability to the computer industry. In addition, hardware is considered tangible personal property in all jurisdictions, thus subject to the property tax.

The status of operational or systems software is unclear. A few states, such as California, have considered the question and have classified this type of software as part of hardware and thus subject to the property tax. Most states, however, have not considered the question, so that very little law is available on the subject. The term of software, when used in the survey, means application (sometimes referred to as applied) software. The question of whether software will be considered tangible personal property is particularly problematical in this area of taxation because local practice may differ as to its treatment.

The survey also notes in this section that a further question arises as to the method of valuation which should be employed if software is deemed taxable since this tax would be imposed on the value of the property on a particular valuation date.

2. Sales tax. This is a tax administered by the state on retail sale and, usually, rental or lease of tangible personal property within the state. The sale, lease, or rental of hardware is considered a sale, lease, or rental of tangible personal property within all states having a retail sales tax. The main question raised in the various state summaries is whether application software, either package or custom, constitutes tangible personal property for purposes of sales taxation. In states making a distinction between operational systems or software and application software, the former has been considered part of hardware, and thus tangible personal property. The status of operational or systems software, however, is largely undecided, and, as with personal property tax, very little law is available on the subject.

The survey points out that in addition to taxation of tangible personal property, many states also impose the sales tax on gross receipts derived from providing certain enumerated services. These services are designated specifically by the statute or are included in the definition of "sale" or "retail sale." The tax on services has obvious relevance to data processing.

3. Use tax. This is, according to the ADAPSO survey, one that complements the retail sales tax and is only found in those states having a sales tax. The tax is levied on tangible personal property "used, stored, or consumed" in the state, where the sales tax imposed by that state has not been paid. This situation normally occurs where tangible personal property is purchased or leased from outside the taxing state for use within. Therefore, a provision is normally included in the statute which allows a credit to the extent a sales tax was paid in the state of purchase or lease. The definition of use, storage and consumption normally includes resale, lease, or release and this should be assumed unless otherwise noted.

COMPUTERIZED ROUTING CAN IMPROVE NEWSPAPER DELIVERIES

News Office
Mass. Inst. of Technology
Cambridge, MA 02139

Computerized scheduling and routing of newspaper delivery trucks has a potential "for real savings and better service," according to a preliminary study by researchers at Massachusetts Institute of Technology. The overall goal of the study was to determine if computerized approaches to newspaper vehicle routing and scheduling are sufficiently promising from the viewpoints of delivery-cost reductions and service-quality improvements to warrant further detailed, in-depth investigations.

The exploratory study was carried out in cooperation with the Worcester (Massachusetts) Telegram-Gazette, and focused on the company's afternoon newspaper, which has a circulation of about 92,000. The study indicated that computerized approaches to scheduling and routing of delivery trucks "should be part of the future electronic environment" of newspaper plants.

In order to conduct the study in "the real-world environment of newspapers," the researchers worked with the staff at the Worcester Telegram-Gazette to assess the requirements of their distribution system. They collected: listings of vehicle routes within the city limits; information concerning the approximately 550 drop points for bulk deliveries; the numbers and sizes of delivery vehicles; vehicle capacities; newspapers per drop point; and other similar, relevant information.

A model was devised that considered limitations on vehicle-loading capacities, the maximum number of drop points that can be assigned to any route, the maximum time that should be allotted to any vehicle's route, and the size of the delivery fleet. By applying this computerized model to the data supplied by the Worcester Telegram, the researchers produced some tentative conclusions:

- The 550 drop points within the city could be covered by a total of 13 routes instead of the 20 being used by the newspaper.
- A routing concept entirely different from the one in use was possible.
- Vehicles could be loaded to more than 50 per cent of functional capacity, averaging 67 per cent capacity; this would be a marked improvement.

The M.I.T. researchers caution that their model was preliminary and did not consider certain policy decisions that led to the current routing pattern. Nevertheless, the findings suggest that improvements are possible, they said, adding that the newspaper's circulation department was intrigued by the fresh approach to routing offered by the computer. □

White – *Continued from page 22*

of the "and," "not," and "or" relations. Three major uses of computers and the systems required for each.
1971 color rental $8.25 19 minutes
University of Michigan

WHOLE EARTH'S INVISIBLE COLORS
Builds an understanding of multi-spectral sensing as a system to explore new ways to look at the earth and its total resources. How this technique expands man's ability to survey earth resources and to diagnose ecological ills; how scientists use computers to help analyze and interpret the images; practical applications for agriculture, forestry, conservation, geography, urban planning and mineralogy.
1972 color rental $9.15 20 minutes
University of Michigan

AND WONDERS NEVER CEASE
Opens with an overview of the development of audio-visual materials in education and continues with today's use of the new media including electronic computers operated by high schools in large city systems. Assures that these instructional materials are an extension of the teacher's personality and that they are tools to aid rather than replace the teacher.
1963 color/sound rental $3.50 27 minutes
Purdue University

YEAR 1999 A.D.
The house of tomorrow is shown, including home-based computers that serve as bookkeeper, banker, shopper, cook, maid, entertainer, librarian and teacher in a look at suburbia by the turn of the next century.
1968 rental $6 26 minutes
The University of Texas at Austin

YOU AND THE COMPUTER
The simple example of preparation of an individual paycheck shows the difference in handdone and computer-handled operations — covers storage, calculation, output and control; the function of the computer memory, how the program serves as instructions.
1969 color/sound rental $4.40 9 minutes
University of Minnesota □

Clagett – *Continued from page 14*

Analysis of Software Costs
During the Year

Task	Time Req'd (Hrs)	Charge Basis	Cost
1. Software Development	200	Fixed Rate	$4,000
2. Modifications (Estimate)	20	$30 per Hour	600
3. Training	16	Included in Development	
4. Long-Range Support	40	$30 per Hour	1,000
TOTAL COST			$5,800

There may be a large difference between the quoted cost for development and the true cost. It's important to compare true cost, as the lowest bid may not actually provide the lowest cost.

Monitoring Development

Monitoring the progress of software development will help you to avoid potential problems and delays. Ask the consultant to submit progress reports, and schedule periodic meetings to review the status of the project. To monitor progress, prepare a chart showing the expected sequence of events during development.

Conclusion

It is quite likely that attention to all the details here referred to will make the difference between the success and the failure of a computing installation. □

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 one way or another to 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 an array of random or pseudorandom digits ("produced by Nature") has been subjected to a "definite systematic operation" ("chosen by Nature") and the problem ("which Man is faced with") is to figure out what was Nature's operation.

A "definite systematic operation" meets the following requirements: the operation must be performed on all the digits of a definite class which can be designated; the result displays some kind of evident, systematic, rational order and completely removes some kind of randomness; the operation must be expressible in not more than four English words. (But Man can use more words to express it and still win.)

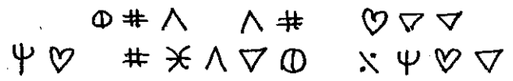
NAYMANDIJ 767

8 0 3 7 7 4 7 4 0 5 1 6 8 7 1 5 8 3 9 8
3 4 0 8 6 5 2 5 2 7 1 0 4 5 4 7 9 1 5 6
7 9 3 4 1 5 3 0 3 5 2 3 6 8 8 2 4 3 3 4
7 6 2 1 3 1 4 8 4 5 0 8 3 1 2 1 4 0 2 3
7 5 8 2 1 5 7 6 8 1 0 5 7 5 1 7 9 0 8 2
3 1 0 0 2 1 0 9 3 4 0 6 6 1 1 4 6 9 1 0
9 5 5 7 8 4 1 8 4 3 3 2 1 6 8 5 6 4 9 2
5 6 0 3 5 4 3 1 0 0 8 1 7 0 7 4 6 9 2 9
4 8 1 5 0 5 6 6 1 2 1 4 8 4 8 3 2 2 8 2
7 1 0 0 4 5 7 8 5 1 0 7 7 9 4 6 4 5 0 2

MAXIMDIJ

In this kind of puzzle, a maxim (common saying, proverb, some good advice, etc.) using 14 or fewer different letters is enciphered (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 KS for X or vice versa, etc. But the spaces between words are kept.

MAXIMDIJ 767



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 deliberate (but evident) misspellings, or is otherwise irregular, to discourage cryptanalytic methods of deciphering.

NUMBLE 767

C = R

P E O P L E
x A R E
O M L P P I L
E P D O L P P
M D C R L D C
= M L P I T L I O L

8124 9786 035

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

SOLUTIONS

NAYMANDIJ 766: Make column 13 odd.
MAXIMDIJ 766: Do the best that you can.
NUMBLE 766: Oak is farmer's iron.

Our thanks to the following individuals for sending us solutions: Choon Kun Choung, San Diego, CA: Numble 764; Numble 765 – Abraham Schwartz, Jamaica, NY: Numble 764; Numble 765 – Dianne King, Warwick, NY: Naymandij 765 – Jim Pate, Birmingham, AL: Naymandij 765; Maximdij 765 – Frank E. DeLeo, Brooklyn, NY: Naymandij 765; Maximdij 765; Numble 765; Naymandij 766; Maximdij 766; Numble 766 – T. P. Finn, Indianapolis, IN: Maximdij 765; Numble 765; Maximdij 766; Numble 766.

COMPUTER GRAPHICS AND ART

FIRST TWO ISSUES NOW PUBLISHED

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

Learning Through Graphics
by Dr. Al Bork, University of California, Irvine, California
A ten-year forecast for computers, education, and graphics by a leading authority.

Art of the Technical World
by Dr. Herbert Franke, Munich, Germany
Computer art as the bridge between the two realms of art and leisure.

Expanding the Graphics Compatability System to Three Dimensions
by Richard F. Puk, Purdue University, Lafayette, Indiana
Design considerations for a user-oriented 3-D graphics system.

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

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

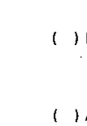
The State of the Art of Computer Art
by Grace C. Hertlein, Editor
Comparisons of early computer art and today's newer art. What is art? What is art in computer art?

Inexpensive Graphics from a Storage Cathode Ray Tube
by Charles J. Fritchie and Robert H. Morriss, Tulane 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. Linehan, Ohio State University, Columbus, Ohio
The new aesthetic of computer art requires a departure from the previous, formalist-traditionalist doctrines for evaluating art.

COMPUTER GRAPHICS and ART is a new international quarterly of interdisciplinary graphics for graphics people and computer artists. This new periodical is aimed at students, teachers, people from undergraduate and graduate institutions, researchers, and individuals working professionally in graphics. Its topical coverage is broad, embracing 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.



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computers and people

formerly *Computers and Automation*

July, 1976
Vol. 25, No. 7

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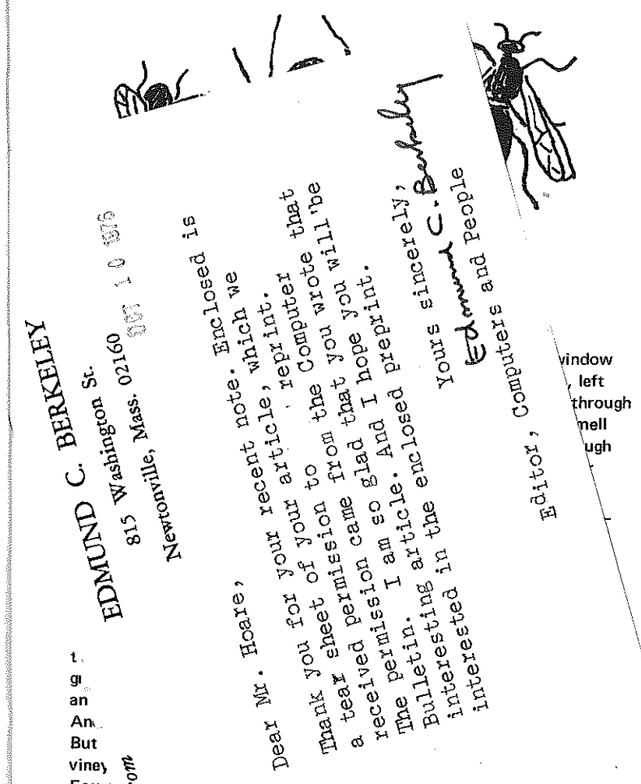

The ... was Engineering Technology. So ... Engineer who lived on the slopes of Mt. Etna, ... liked the balmy climate and the view of the Mediterranean Sea and the excitement of watching his instruments that measured the degree of sleeping or waking of Mt. Etna. The Fox put his problem before the Engineer . . . .

The Fire Squirrels

Scene: Two squirrels, a young one named Quo, and an older one named Cra-Cra, are sitting by a small campfire in a field at the edge of a wood. Behind them hung on a low branch of a tree are two squirrel-size hammocks. Over each of the hammocks is a small canopy that can be lowered to keep out biting insects. It is a pleasant summer evening; the sun has just recently set, and the stars are coming out: ——

Quo: Cra-Cra, you know I don't believe the old myths any more. Tell me again how it really happened.

Cra-Cra: Just this: we received our chance because they dropped theirs. It is as simple as that.

Quo: In other words, they were the first animals to use tools, and we are the second?

Cra-Cra: Yes. There is a mode of surviving in the world . . . .

Missile Alarm from Grunelandt

Once upon a time there were two very large and strong countries called Bazunia and Vossnia. There were many great, important, and powerful leaders of Bazunia who carefully cultivated an enormous fear of Vossnia. Over and over again these important and powerful leaders of Bazunia would say to their fellow countrymen, "You can't trust the Vossnians." And in Vossnia there was a group of great, important, and powerful leaders who pointed out what dangerous military activities the Bazunians were carrying on, and how Vossnia had to be militarily strong to counteract them. The Bazunian 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 Grunelandt far to the north of Bazunia.

Now of course ballistic missiles with nuclear explosives can fly any kind of a path all around a spherical world, and they do not have to fly over northern regions. But this kind of reasoning had no influence on the leaders of Bazunia who wanted the money for building BMEWS. Nor 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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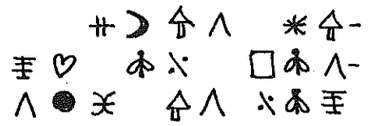
The magazine of the design, applications, and implications of information processing systems — and the pursuit of truth in input, output, and processing, for the benefit of people.

Front Cover Picture

The world's largest mosquito, the cannibal, may help control other mosquitoes which carry encephalitis and other diseases. Scientists at the University of Notre Dame are using the cannibal and a computer to help develop nonchemical strategies for combatting mosquitoes.



Key

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EDITORIAL

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
Tenait en son bec un fromage;
Maître Renard par l'odeur alléché
Lui tint à peu près ce langage:
"Eh, 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 him 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

Edmund C. Berkeley
Editor