COMPUTER

USAGE

FALL ISSUE 1966

VOL. 1 - NO. 4

THE SOFTWARE CRISIS

by Cuthbert C. Hurd

We face a critical shortage in human resources, a crisis in software.

In fifteen years of successful computer usage, computer users have developed a set of information processing tasks which could and should be performed.

In those same fifteen years, computer manufacturers have made numerous technological break-throughs and have only recently started installing their "third generation" hardware—with "second generation" programming systems.

Those functions which depend directly and intimately on human participation — problem definition, systems analysis, programming, machine operations, and, most importantly, management — comprise what is generally called software. Software is in short supply.

This shortage, while adversely affecting many industries, has already reached crisis proportions in some areas — for example, in the data-dependent banking industry. In one area of banking alone — the processing of checks — electronic data processing has proven its value.

Several studies I've seen suggest that the 15,000 U.S. banks now process over 20 billion checks annually — as opposed to about only three billion in 1940. The total value of these checks has been estimated in excess of $2 trillion annually and it takes over 500,000 bank employees to handle the formidable paper barrier thereby created.

It was the banking industry that broke ground as commercial users of computing equipment sixteen years ago. Perhaps the initial impetus was provided by the processing of checks, creating the need for new computing systems, and an industry standard in Magnetic Ink Character Recognition (MICR), adopted by the American Bankers Association back in 1959.

And yet, the same banking needs and bankers' ingenuity that brought early use of computing equipment to this field is one of the forces that is creating our present software crisis. Dozens of modern banking applications — like personal trusts, corporate trusts, payroll, savings accounts, mortgages, factoring accounts— frequently require the transmission and storage of hundreds of thousands of records, usually under severe time pressures.

Larger banks, with few exceptions, use computers in bookkeeping, for customer service, and in a beginning way for operations research and central information files. Smaller banks are beginning to follow suit. Nevertheless, every banker with whom I talk looks forward to the time when information processing can serve him as a direct aid to management planning and as an aid to management decision making.

Here too, the other factor in this software crisis — the proliferation of sophisticated hardware — can be seen.

Computer manufacturers have combined their systems experience and the rapidly developing component technology to produce hardware systems of compatible families which offer a wide range of modularity and choice in processors, memory and input/output configurations. One manufacturer, for example, offers nine machine systems, thirty-one memory and processor combinations, and seventy peripheral and input/output devices.

Functionally, some of these machines are able to perform not only batch processing, but multi-processing, real-time processing and time-sharing. At the same time, all manufacturers are supplying elaborate programming systems which include operating systems, problem-oriented processors and special application programs. This combination of hardware and programming systems offers in principle a cost/performance improvement factor of perhaps 100 over information processing systems of two decades ago.

The trick is to find the software capability to apply the systems to the application and thus realize the cost/performance advantages.

It might be of some value to look more deeply into the nature of current software — particularly as it relates to current and projected hardware developments. The resulting perspective should provide some constructive insights into means of alleviating the software crisis.

THE REPROGRAMMING PROBLEM

The programming function in 1966 places almost equal importance on reprogramming to install the new generation of computers as on the programming associated with new application and development.

Regardless of compatible families offered by the manufacturer and of certain compatibilities between the families of various manufacturers, the reprogramming problem will be with us as long as the technology of the computer industry continues to change rapidly. This is true even though problem oriented languages such as FORTRAN, COBOL and dozens of others are becoming increasingly popular and widely used.

It is fortunate, however, that programming, even though a young field, is sufficiently well understood and sufficiently well defined that the computer itself can assist to a degree in reprogramming.

Let me only mention that emulators now offered by several manufacturers assist in easing the reprogramming problem and that simulators, translators and compilers written in their own higher level language can each reduce reprogramming time and expense by some fraction.

Remarks based on a paper given at the National Automation Conference of the American Bankers Association

HANDS ON — OR HANDS OFF

One of the most expensive and time-consuming aspects of programming new applications is check-out — or, in the vernacular, debugging — time. Many workers in the field of time sharing believe that turn-around time and therefore total elapsed check-out time of programs will be greatly speeded by time-sharing systems. Verification of this expectation can come only as time-shared systems with appropriate software are delivered this year and next.

The task of operating the computer facility in 1966 is characterized by testing the most elaborate "Operating Systems" which have yet been devised. Operating Systems were originally thought of in about 1953 and developed over the next decade into systems which were oriented toward overlapped setup in sequentially executed job batches. Influenced by the real-time demand of the military, NASA, and reservation systems, modern operating systems also permit tasks from a number of different jobs to be processed simultaneously in a multi-processing mode. Buffers, multi-level interrupts, and a variety of "move" instructions both facilitate the operating system and make it more complex.

Every manufacturer is supplying one or more operating systems with his computers and under these systems both personnel and machines will be given directions and instructions from the computer system.

There is a curious paradox that operating systems of such a high degree of power and complexity should be made available in the same year that time-sharing systems are being made available. That is, due to the increasing cost per second of the Central Processing Unit and the increasing complexity of operating system in which multi-processing with consequent powerful interrupting is available, it has been thought more and more desirable to get first the programmer and then the operator away from the machine. The statement has been made that a $10 a minute machine cannot afford to wait while a human makes a decision. On the other hand, time-sharing again puts the man back directly in contact with the Central Processing Unit through the use of terminals and elaborate software. It will be interesting to determine by experience which concept is correct or whether some combination of these two concepts is even more efficient.

SIGN OF THE TIMES

If my thesis is correct — that there is a critical and worsening shortage of software capabilities — we should be able to read the signs clearly.

Quantitative indicators of the shortage of software capability are given by the number of "help wanted" advertisements in newspapers, magazines and professional journals; by the number of recruiting notices appearing on the bulletin boards of colleges and universities; by the number of professional placement agencies in the information processing field which have sprung up in the last five years and by the number of specialized training and educational organizations which have been established to educate analysts, programmers and to train operators. More importantly, both the manufacturers of computers and the users of computers have been revising their installation schedules, at least in part, because of lack of sufficient software capability.

The shortage of highly experienced and qualified software professionals was brought home to me forcefully early this year in the following way. Because of increasing demand for our consulting, analysis, and programming services in the software field, CUC decided to increase its staff by 25%. This implied recruiting a hundred experienced software personnel. We accomplished this task in the first quarter of 1966 but only through the application of great amounts of management time and at enormous expense.

INFORMATION PROCESSING — A MANAGEMENT FUNCTION

Once recognizing the crisis upon us, several remedial steps come to mind. I believe one of the most effective means of lessening the impact of the software shortage is to upgrade the quality of management of information processing.

The most obvious remark to make about this function is that it requires an increasing amount of top management attention.

Measurable information processing costs in some well managed and profitable large organizations already constitute 10% of total corporate operating costs. Such sizeable expenditure demands attention in any case. More significantly, information processing costs have expanded rapidly in the past and even though leveling out slightly at the present time give every indication of increasing rapidly again. Clearly, management should watch those areas of expense which are not only large but which also have a large rate of increase.

Secondly, information processing should be viewed and considered from a management technique point of view in the same way as any other principal operating function within the organization. That is to say, it should not be viewed by top executives as a mystical black art, but rather should be treated in a professional management manner and with emphasis on plans, execution, measurement and control.

". . . PRIZE HIM LIKE A JEWEL"

Somewhat distinct from, but related to, the management function is the problem of developing a high level systems analysis capability.

In the areas of problem definition and systems analysis, the most important dictum is: "find a good man and prize him like a jewel." The quality of systems analysis has the most far reaching effect on the whole information processing activity.

It is literally true that orders of magnitude of increased efficiency of information processing can be achieved at the systems analysis level. Management can afford to spend considerable time in helping recruit systems analysts. Verifiable, successful, previous experience is the most important attribute in a candidate. Among other things, such experience will enable him to define a system for you which is large enough to make its output interesting and helpful but not so large and complicated that the system is intractable.

AVAILABLE SOFTWARE RESOURCES

While the upgrading of information processing management and the development of systems analysis capabilities will cushion the software crisis' impact over the longer term, immediate help is available from three main software resources. Independent software firms have increased rapidly in number, size and influence in the past decade. In addition, consulting organizations in a variety of other areas have expanded their services into the software field. Finally, particularly for the military and for NASA, manufacturers of computers and/or other kinds of space hardware are offering software systems both independently and as a part of Space Systems.

Banks, for example, now use outside software resources to supplement their own. These services cover the whole range from problem definition to assistance in and sometimes complete responsibility for machine operations. The principal motivations are calibration, load leveling and the attraction of outstanding experience. By calibration I mean that a bank might wish as a matter of policy to contract out a certain fraction of its software work and thus obtain comparisons of cost and efficiency with respect to its own staff. Load leveling is desirable because there is not a continuous and uniform flow of new application development or of the installation of new systems. No bank could possibly afford to keep a sufficient number of qualified professionals to meet every peak load, therefore it levels the load by outside contracting. Finally, expertness is by definition rare, and a bank or any other organization may need to go to a consulting firm in order to find it. *It is my view that the use of outside software services will continue and will increase rapidly.* The primary reason is that software is becoming a profession and that many highly qualified men and women wish to regard themselves as a member of that profession and to find employment in an activity which highlights that profession. Indeed, many of the employees of my firm join us for the specific reason that they are interested in software per se as a means to solve problems and they believe that the variety of application opportunities which are presented by a consulting firm greatly enhance their professional growth.

SOFTWARE — 1970

It is worthwhile to consider what the future software environment will be. In the first place, we can expect a new generation of computers in the early 1970's. That is because component technology continues to change rapidly and the successful development of monolithic circuitry holds the promise of producing a thousand elementary circuits or a thousand bits of ultra high speed storage or some combination of these two on a single silicon chip the size of a quarter. Spokesmen for the component industry predict that such technology may produce circuits at a nickel apiece and ultra high speed storage at a nickel a bit.

This implies the unassembled and untested cost of a present day high speed Central Processing Unit at about $1500. At the same time, however, there is no indication that machines will be less complicated in the 1970 period than at the present. Thus n[illegible]ly will the reprogramming problem again be with us in the next five years, but we will be programming machines which may be even more complicated than the "third generation" machines.

I am sure that the semi-automatic reprogramming techniques described above will be more fully developed by 1970. Also I am sure that some of the advanced programming techniques such as the use of macros, syntax-direction, meta-assemblers, etc. will be more fully refined. However, there is also the possibility [illegible]at the increased complexity of machines will more than co[illegible]er-balance the improvement in programming efficiency. All of this leads me to the conclusion that the software man will be in even greater demand in 1970 than in 1966.

Dr. Cuthbert C. Hurd has been Chairman of the Board of Computer Usage Company, Inc. since 1962.

A pioneer in the electronic computer field, Dr. Hurd previously served the International Business Machines Corporation, where he was a key figure in its move to computers in 1949.

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COMPUTER USAGE is a publication of Computer Usage Company, Inc., 344 Main Street, Mt. Kisco, N. Y. 10549.