Field Guide to Computers, Their Habits & Habitats

Part VII: The World of the Future

Last month's article described some of the ways in which computers are currently being used at the Laboratory. This month, in the last article of this series, Jim Baker examines some new developments in computer hardware and software and predicts the effects of these new developments on the ways in which computers will be used in the future.

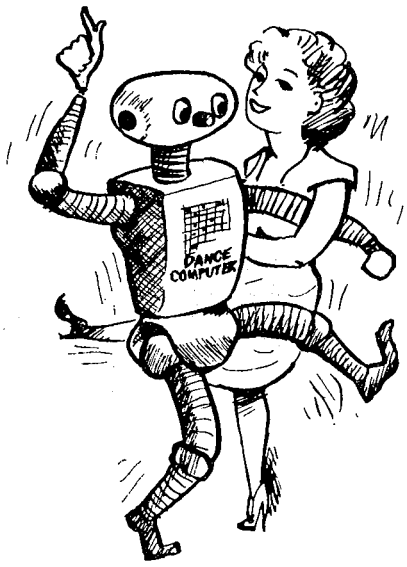
The computing machines which will be installed in the United States starting next year (an early forerunner of these was the Control Data 6600, delivered to the Livermore Lab two months ago) will be quite different from the machines that have been installed to date. They will be faster by a factor of ten or so; their memories will be up to four times as large; and they will be equipped with much faster and more sophisticated input-output devices than were their predecessors. These hardware changes will have a profound effect on the ways in which computers are used.

At computer installations where the problem load involves a fair amount of input-output (such as LRL's Berkeley Laboratory), the installation of a computer whose arithmetic unit is ten times faster does not necessarily mean that one will now be able to do ten times as many problems in the same time period. If we attempt to run our problems in the conventional way, we will spend most of the time on our computer waiting for input-output tasks to be accomplished; the central processing unit will be idle for a large share of the time. One way to remedy this situation would be to acquire input-output devices which were faster than existing ones by a factor of ten. Unfortunately, such devices are not readily available, so we must seek another solution to this problem.

Multiprogramming

The solution that will be adopted at most large computer installations is known as Multiprogramming. This concept involves having the programs for several problems in memory at once. These problems all share the computer's central processing unit, but each one is assigned its own peripheral input-output devices—tape drives, for example. If we have a reasonable mix of problems, and if we are clever in writing a program to allocate our computer components among these problems, we can expect to keep a reasonable number of machine components busy at the same time; one code may be using the central processing unit, for example, while three others are simultaneously performing tape input-output functions. Under such a system, the elapsed time for doing a set of problems will be substantially reduced.

Most of the machines which are scheduled for delivery starting next year will have hardware capabilities which allow them to be multiprogrammed. Such hardware capabilities include large memories (we must have enough space to get several codes into memory at once), several input-output channels (we must allow several programs to be performing input-output tasks at the same time), and memory protection devices (we must prevent the program which has control of the central processing unit from destroying other programs which share the memory).



The programs which control the scheduling of problems on the computer and the allocation of computer hardware are called Monitor Systems. A limited multi-programming monitor system, called Diprogramming, has been in operation on a 7094 computer at the Berkeley Laboratory for about six months. It was described in the August issue of the MAGNET. A more sophisticated Multiprogramming Monitor System for the Control Data 6600 is currently under development at the Livermore Laboratory.

In the future, Multiprogramming Monitor Systems will be provided by the manufacturers of all major computers. Such systems are already available for the Honeywell 800 and UNIVAC 1107 Computers.

An important consequence of the availability of multiprogramming systems on new computers involves the way in which card input and printer output will be handled. The user who now wishes to submit a problem for solution on a large-scale computer turns in a deck of cards with his program on it; this deck of cards is then combined with several other decks and taken to a small auxiliary computer such as an IBM 1401, where the cards are transcribed onto a reel of magnetic tape. This tape is then transferred from the 1401 computer to the large-scale computer, and the problems on the tape are done in sequence. The large-scale computer, instead of printing the answers on its on-line printer, writes them out on another reel of magnetic tape. When all the problems in this sequence have been completed, this printer tape is transferred to a 1401 computer, which performs the actual printing. The reason for all this tape manipulation lies in the sequential way in which problems are done on current large-scale computers. If one were to read cards on-line or print on-line, one would idle all other components of the machine—an intolerable condition.

SPOOLing

When a mulitprogramming system is available, this whole situation changes; it now becomes perfectly feasible to print on-line and read cards on-line and, at the same time, to utilize many other components of the computer. This type of activity is called SPOOLing, which stands for Simultaneous Peripheral Output On-Line. In the bright world of the future, the user will simply insert his problem deck into a card-reader attached to a large-scale computer; the computer will then read his cards in and store them on an auxiliary storage device, such as a magnetic disk. When the problem reaches the head of the queue and when memory space becomes available for it, the Monitor System will load it into the memory and begin executing it, probably in conjunction with several other programs. Printer output will be written on a disk; as soon as an on-line printer becomes available, the output will be printed. The availability of this SPOOLing capability should dramatically decrease the elapsed time between the submission of a program deck and the return of printed output.

The possibility of more intimate man-machine relationships is another important consquence of multiprogramming systems. Under ideal conditions, the user of current hardware and systems may expect a two-hour delay between the time he submits a problem to the computer and the time he gets his output

back. Quite often, when he looks at his output, he discovers that he has omitted a comma in a FORTRAN statement, or that there has been a keypunching error in the preparation of his data, or that the hypothesis he was testing in his program is false and that he now wishes to try another one. In any of these cases, the user may require only a few minutes of looking at his output before he is prepared to submit another program. After submitting the program again he must, of course, wait another two hours. This is a very inefficient way of using people. One possible solution to this problem would be to provide each user with his own computer; he could sit at the console of his machine and obtain immediate turn-around on his problem, since there would be no people queuing up in front of him. This, of course, is not a very efficient way of using computing machines—even if one had enough money to buy that many machines.

User Consoles

A compromise solution will be found in a variety of user display and inquiry consoles that will be available with the next generation of computing machines. These consoles, which may be installed at remote locations, will be connected directly to the central computer system. The simplest of these consoles is a typewriter or teletype machine — supplemented, perhaps, by a card reader. More complicated consoles include a cathode ray tube display system, which can be used for either graphical or alphanumeric output. The user will employ these consoles as debugging devices or as quick-response mechanisms in the solution of problems.

The Livermore OCTOPUS System, which was described in a previous MAGNET article (September '64), will employ several consoles, each consisting of a teletype machine and a small pen-and-ink plotter. In Berkeley, consoles of two types will be used: typewriter and card reader stations will be used for program debugging, and CRT plotters equipped with keyboards and light pencils will be used as on-line physics consoles.

New Problems

The increased computing power of future computer generations, and the increasing sophistication of programming systems available for them, will allow the computer user to attack larger problems than ever before. For example, Livermore scientists will be able to undertake much more detailed simulation of weapons systems, and Berkeley scientists will tackle the analysis of larger experiments than in the past. Moreover, it will now be possible to solve effectively some entirely new problems. One of these which has been much discussed is the pattern-recognition problem for bubble chamber events. Over the past few years the Berkeley Laboratory has developed some extremely speedy devices for measuring the location of points on bubble chamber film. However, present systems demand that all film be scanned by a human scanner in advance of measurement. This human scanner is the pattern-recognition element in the system. In the future, it is hoped that this pattern-recognition role can be taken over by computers; such systems are currently under development by Howard White and his co-workers and several other groups at the Berkeley Laboratory.

At present, when a computer user wants to solve a specific mathematical problem he is forced to spend a great deal of time matching his particular version of that problem with the available numerical techniques, and with computer programs which implement those techniques. He must match the appropriate code to his problem. This is often a fairly time-consuming process. In the future, it is hoped that much of this work can be taken over by the computer; for example, the user may someday merely submit his differential equation for solution, specifying the range over which the solution is needed and the required accuracy. The computer would then analyze the differential equation, select an appropriate solution technique, and pick out of its library a code which implements that technique. Here, the computer would take over some of the functions not only of the programmer, but also of the numerical analyst.

Advances in list-processing and in the manipulation of symbols by computers should make possible the creation of routines capable of performing many of the algebraic manipulations which now constitute something of a national sport among theoretical physicists. The least we may confidently expect of such routines is that they will be capable of the formal manipulation of infinite series and of the simplification of algebraic expressions. These manipulations will probably be accomplished with the assistance of the display consoles mentioned earlier.

Exotic Applications

Many new and exciting computer applications can be expected outside of the Laboratory's research areas during the coming years as well. For example, computer-assisted engineering design applications, already being written, will permit a mechanical engineer to interact very closely with a computer. In this application, the computer will play the role of a sort of high-speed calculator and draftsman.

Somewhat farther off is the development of fully-automatic, high-quality mechanical translation from one natural language to another. This development will surely be stimulated by the increased speed and memory size of the computers now becoming available.

Effective computer-assisted weather forecasting is probably somewhat closer than effective mechanical translation. The availability of high-speed computers, together with the presence of increasing amounts of data from weather satellites, should make this development possible in the near future.

Finally, the use of computers in teaching, to extend existing programmed learning techniques, will be extremely important.

Gilbert Lewis Lecture Given by Leo Brewer

Leo Brewer, head of LRL's Inorganic Materials Research Division and professor of chemistry on the Berkeley campus, presented the Eleventh Annual Gilbert N. Lewis Memorial Lecture on Friday evening, October 23 at the new Physical Sciences Lecture Hall.

The Lewis lectures were established at Berkeley in 1953 through a bequest of the late Dr. George A. Linhart. Providing an opportunity for public report of notable work in chemistry, they honor the memory of the late Dr. Lewis, professor of chemistry at Berkeley from 1912 until his death in 1946, and widely regarded as a world leader in chemistry research and education.

EXTRA COPIES?

"A Field Guide to Computers," the series which ends in this issue, will be reprinted as UCRL #11753, and will be available through the Technical Information Division. Please submit requests in writing to Technical Information Division, Bldg. 30, Rm. 101, LRL Berkeley. The reports will be distributed as soon as they are ready.