

## F. T. McCLURE COMPUTING CENTER DEVELOPMENT

The development of APL's F. T. McClure Computing Center has been guided by two complementary needs: computing power (capacity) and specific capabilities.

Computing power is a measure of how much computing can be done per unit time, regardless of what is being computed or the mode of man-machine interaction. It is measured in operations per second and has grown, since 1966, at an average annual compound rate of about 18%. The growth has been impelled by

1. Growth in the staff during the early years;
2. The change in work habits of the staff to take advantage of increasing computer capabilities;
3. The shift in APL programs made possible by those capabilities (Transit, Submarine Technology);
4. The additional computing load of new capabilities such as interactive computing, on-line graphics, and image processing.

Since the growth rate of required computing power has been steady (on the average) over the years, predictions of the requirement and justification for the resources to meet it have been quite straightforward, once the trend was established.

Specific capabilities offer a very different set of prediction, justification, and management problems.

The first computers, the IBM 650 in 1956 (Fig. 1) and the Univac 1103 in 1957 (Fig. 2), were run in batch, one job at a time. For the 1103, even the assembler was developed in-house, as was a Polish-prefix algebraic language (APT).



Figure 1—IBM 650 computer, installed in 1956.

Acquisition of the IBM 7090/1401 combination in 1959 (Fig. 3) provided the Fortran language to the APL computing community, with access to programs written by a much larger community of Fortran users. Although still restricted to batch, several jobs could be submitted to the system at one time, in both assembly language and in Fortran. The existence of separate channels made it possible for computation to proceed in parallel with input/output operations. Beginnings were made in information retrieval and text processing during that period, and the Laboratory's financial work was shifted to a separate IBM 1401.

The system grew to an IBM 7094 in 1962 and then to two 7094s in 1963. The 1401 was replaced by an IBM 7040 and an IBM 1410 in response to the mentioned growth in required computing power. The hybrid facility was developed in that period, with the central computer as its digital component.

The arrival of the IBM 360/91 (Fig. 4) in 1967 gradually provided several important new capabilities. The multiprocessing operating system (Multiple Variable Tasking) permitted several jobs to be run at a time. This provided more efficient use of system facilities because, for example, one time-shared job could use the central processing unit while another was waiting for input or output.

While Fortran remained in wide use, the PL/I language spread rapidly and the APL language more slowly.

The major new capability during the period was interactive computing, in which the user converses with the computer via an on-line terminal while his job is being run. On-line graphics capability also appeared at this time but as a scarce and expensive resource available only to a few users.



Figure 2—Univac 1103-AF computer, installed in 1957.



Figure 3—IBM 7090 computer, installed in 1959.



Figure 4—IBM 360/91 computer, installed in 1967.

Access to the equipment by a large number of users outside the Laboratory required a more formal means of communication between users and the Computing Center. The user clinic and the document series initiated in response to this requirement remained permanent features, even after their need by outside users diminished.

An IBM 370/158 was added to the system in 1976 to provide experience with the 370 technology. In 1979, the 360/91 and 370/158 combination was replaced by a pair of IBM 3033s (Fig. 5) in multiprocessor configuration to meet the continuing growth requirement, in order to avoid the reliability and maintenance problems of obsolete equipment, and to satisfy security requirements.

In January 1983, the central computing system was expanded to include an IBM 4341, primarily to facilitate the interactive use of the system. This part of the system uses the Virtual Machine/Conversational Monitoring System (VM/CMS) and will provide software systems, such as UNIX and PROFS, of demonstrated utility to this class of users.

Figure 6 shows the current and proposed configuration of the Computing Center and also indicates the increasingly vital connections to other installations.

In the meantime, the personal computer explosion has sent its shock waves through APL, on the one hand giving the staff more immediate control over a portion of their computing needs and, on the other hand, increasing pressure for communication between central files and personal workstations.

The combination of adequate computer capacity, inexpensive graphics terminals, and interactive graph-



Figure 5—IBM 3033 multiprocessor, installed in 1979.

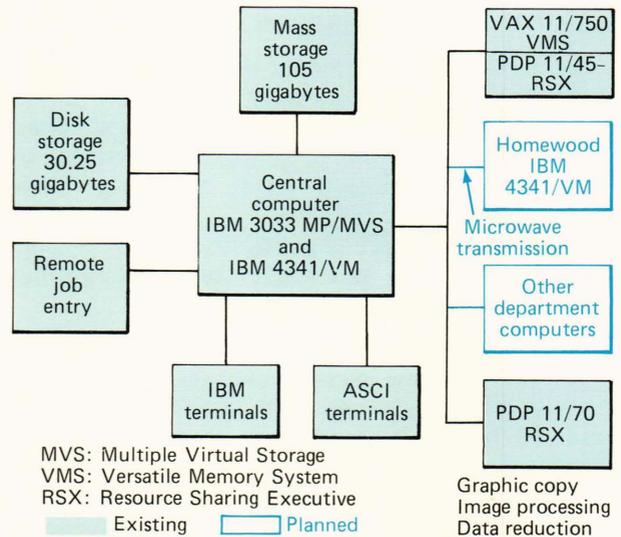


Figure 6—The current and proposed configuration of the F. T. McClure Computing Center.

ics software moved APL quickly into the area of interactive computer graphics. The development of the Graphics Laboratory offered complementary off-line support to this activity.<sup>1</sup>

While these developments were taking place in the Computing Center, many other computers had also been introduced into APL, ranging from the major Systems Engineering Laboratory installation in the Strategic Systems Department to PDP-11 computers throughout APL. The need for communication among these computers and with the central system has become increasingly insistent; networks to satisfy this need are under development. It is anticipated that this new capability, like the others mentioned above, will add its impetus to the growth requirement.

The nature of the interaction between the two complementary needs of capacity and capability in the APL environment should be clear, at least in outline. A new capability (such as interactive graphics, for example) is made available in anticipation of effective use, the actual use of the new capability increases the

computer capacity required, provision of the additional capacity makes possible the provision of another new capability, and so on.

The steady improvement of hardware capacity and capability has been accompanied by improvements in programming languages and tools and by software packages such as SAS for statistical analysis, NAS-TRAN for structural analysis, and INQUIRE for database management and interrogation. The trend is continuing, with the DoD-sponsored Ada language for embedded computing and the growth in interest in LISP and PROLOG to support work in expert systems, computer vision, and other advanced areas of computation.

I have sketched the growth of computer technology at APL, but the even more amazing sociological

change deserves at least a comment. Twenty-eight years ago, programmers could be counted on the fingers of one hand, and anyone who wanted answers from a computer got them through the skills of those programmers. The change in a society where commercials for computers even more powerful than the Univac 1103A appear on the Saturday morning cartoon programs is reflected in the continuing effort to make the strength and economy of computer functions available to a wider and wider APL clientele in a more and more natural way.

#### REFERENCE

<sup>1</sup>J. O. Jenkins, J. P. Randolph, D. G. Tilley, and C. A. Waters, "The APL Image Processing Laboratory," *Johns Hopkins APL Tech. Dig.* 5, 59-78 (1984).