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COMPUTER TECHNOLOGY FORECASTING AT THE NATIONAL LABORATORIES *

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INTRODUCTION

The several government-owned contractor-operated laboratories of the Department of Energy fall heir to a rich heritage of computing innovation dating back to the days of the Manhattan Project, through two decades of the patronage of the Atomic Energy Commission, and the short-lived ERDA era. By any measure, the Department and its contractor laboratories represent a computing-intensive organization with a large computing investment in manpower, hardware and software. One of the best ways to protect that investment and insure a cost effective future is by careful planning. And, of course, one cannot make any meaningful plans for future computer acquisition or utilization in such a dynamic field as electronic data processing without making some educated guesses regarding what technology will have wrought a few years hence. Recognizing this, the DOE Office of ADP Management organized a group of scientists and computer professionals, mostly from their own national laboratories, to prepare an annually updated technology forecast to accompany the Department's five-year ADP Plan, which itself draws from submissions from all the constituent institutions.[1]

The activities of the task force were originally reported in an informal presentation made at the ACM Conference in 1978. This presentation represents an update of that report. It also deals with the process of applying the results obtained at a particular computing center, in this case at Brookhaven National Laboratory.

FORECASTING METHODS

One must approach the forecasting of trends in technology with a good deal of humility. Past efforts at technology projections have exhibited an accuracy that decreases exponentially with time. Thus, precisely defined projections beyond about three years should be used with considerable caution.[2]

There are many ways of classifying methods of projection. Obviously, the analyses can be classified into subjective and objective approaches. Subjective methods depend upon opinion, while objective methods depend upon facts, extrapolation, correlation, and analogy. In a field like computer science, however, where there is generally a healthy amount of disagreement among experts, one person's fact can be another person's opinion, and yet a third person's folly. So while a group charged with forecasting may try to take as many objective readings as possible, consensus and persuasion figure heavily into the results.

There are several pitfalls which may ruin a perfectly reasonable technical consensus. One is the possibility of unforeseen scientific breakthrough. Another possibility is the effect of business considerations on technological progress and product availability, since much of the development and almost all of the marketing are done by commercial enterprises. These considerations cannot be easily dealt with and are considered occupational hazards of those who would set themselves up as "experts".

Recent studies conducted to determine the efficacy of technology predictions uncovered some interesting observations:

1) even ill-defined predictions that covered more than a ten-year time frame were right only 40% of the time;

2) experts predict only slightly better than non-experts, and

3) the <u>effects</u> of events are even more difficult to predict than the events themselves.

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For these reasons, it is imperative to include contingency planning in the long-range planning process.

The modus operandi of the DOE task group was to meet periodically over several months preceding preparation of an annual report. The members had been chosen with the idea of getting good representation for the various facets of the computing arena. Hence, topical expertise could be identified and the participants were given the "homework" assignment of preparing a paper in their field. At subsequent meetings the papers were critically reviewed by the entire group. The final report contained a hierarchy of information, reflecting the many purposes of such a document and the diversity of people who might consult it. A short summary, a digest of the topical areas, and several appendices including a description of the forecasting method, the full topical reports, a bibliography, and a glossary were all provided.[3]

At the national laboratories this document was received concurrent with the ADP Plan Call. Surely, it is only one source of information about the future. The person responsible for the Plan at the laboratory had also doubtlessly received information from the vendors, from the upward press of demands from users, and from larger and more scholarly works appearing in the computer science literature, which exist in abundance.

One of the largest such reports was a recently published Proceedings of the Conference on Computing in the 1980s held in Portland, Oregon.[4] This document represented the results of an interactive workshop involving invited experts, technical observers, and public participants. Subsequent to the workshop, the participants drafted a position paper for circulation among their peers. The Proceedings represent, then, the "second order approximation". It thus appears that the so-called Oregon Report was prepared in a similar fashion to the DOE document, except on a far grander scale. A cursory examination of the two documents reveals little disagreement on what the basic issues and trends of the next decade seem to be. As one might expect, while the Oregon Report was more comprehensive, the DOE report is perhaps more relevant to the particular needs of the National Laboratories.

TOPICAL NOTES AND ISSUES

In summary, the following general observations were noted by the task group:

- Mainframe capability of up to 100 times the throughput of the largest existing machines is necessary to solve problems in certain of the most critical areas, primarily in the national defense programs. This must be accompanied by an order of magnitude increase in reliability and a similar increase in storage capacity. This kind of performance will not be available in the next five years unless there is great progress in components, innovative architectures and the development of special processors.
- In the area of peripherals, substantial progress is anticipated in storage, microfilm and printing output devices, and keyboard and display terminals. However, it may be several years before sufficiently fast and large online mass storage systems are readily available.
- Networks, both local and global, require faster and more reliable data channels. One area where industry has not made sufficient progress is in network protocol development.
- Security similarly has not been stressed sufficiently to be dependable for the more sensitive DOE applications.
- Operating systems and application software do continue to receive considerable attention but more reliable, efficient, flexible systems and user tools are needed before the benefits of computing can be extended into areas where they can be used by a wider community of users, including, for example, semi-skilled personnel.

Even in areas where the current technology is sufficient, the amount of equipment needed makes cost an important consideration. One very favorable trend in computing is the decrease in cost of communication facilities, logic circuitry, and memory.

One of the other issues noted was the growth of personalized computing and its effect on the role of the traditional computing center. It was concluded that the current controversy of whether centralization or distribution of computing power is to be preferred is fictitious, and both trends will be important to the National Laboratories in the foreseeable future.

To bring the above issues into clearer focus and remedy the deficiencies, it was recommended that an intensified dialogue take place between the DOE community and industry. This would include increased participation in user groups by laboratory personnel, wide distribution of the ADP Long-range Plan, and the organization of meetings for special topics, all of which also serve to enhance knowledge of the future.

APPLICATION TO A PARTICULAR INSTALLATION

Superimposed upon this scenario of industry-wide trends were a set of assumptions particular to each of the constituent DOE laboratories. Brookhaven National Laboratory (BNL) is used here as an example. It is a basic research laboratory whose data processing organization is somewhat analogous to that of a large university. It has a traditional computing center containing a Control Data Cyber 76 and two aging 6600 mainframes. There are also a large number of small and mid-size computers with more specialized purposes and restricted access.

It is expected that the computing needs of the Laboratory will increase significantly over the next decade. An important part of this increase will come from new applications of computers and the remainder from the expansion of "conventional" computing. To fulfill these needs some new major hardware acquisitions and new software developments will be necessary. Available funding for computer services will grow much more slowly than the ability to make use of such services. Expected increases in cost effectiveness will only partially compensate for this gap.

To meet these needs, the BNL computing environment will consist of a physically and logically distributed assortment of processors, user terminals, and other hardware, coupled by means of a local network. The transition to a network based environment will take place in an evolutionary manner, existing processors maintaining a significant role for a considerable time. The network will be highly modular, allowing the greatest possible logical isolation and operational economy for individual nodes. The present central facility will evolve into one or more nodes of the network, emphasizing equipment and facilities to be shared between programs. Other presently existing systems may also become part of the network. New general purpose systems and special purpose machines will be added in a phased manner. At least one node will provide coupling to remote users and other networks.

The initial task is to lay the groundwork for the distributed network. Given the modest resources of the Laboratory for mounting full scale computer developments, the computer architecture is likely to be based upon an architecture which is a current imminent offering from commercial vendors. This kind of detailed planning is now underway.

SUMMARY

Computer technology forecasting is a difficult and hazardous endeavor but it can reap considerable advantage. The forecast performed on an industry-wide basis can be applied to the particular needs of a given installation, thus giving installation managers considerable guidance in planning. A beneficial side effect of this process is that it forces installation managers, who might otherwise tend to preoccupy themselves with immediate problems, to focus on longer term goals and means to their ends.

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