THE AD HOC COMMITTEE ON FUTURE COMPUTER NEEDS AT FERMILAB

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Introduction

This committee was formed at the request of the Director, as an ad-hoc group charged with reviewing Fermilab's computing needs for the next five to ten years and making recommendations as to possible means of satisfying them. An important by-product of this task is to increase the awareness of the general community to the current state of computing and to the direction in which it is moving. As a result, the report under preparation (for publication in December 1983) contains not only specific recommendations to the Director but also significant tutorial material. In this short discussion, I shall attempt to summarize our report and the procedure by which we arrived at our conclusions.

Committee Membership and Procedure

The Committee consisted of the following members:

J. Ballam, SLAC, Chairman
J. Butler, Fermilab
K. King, Cornell
P. Kunz, SLAC
D. Linglin, CERN
G. Lynch, LBL
H. Newman, Caltech
R. Peierls, BNL
D. Quarrie, Fermilab
M. Schaevitz, Columbia

With representation from high-energy physics labs both in the USA and Europe, good comparisons between the situation here at Fermilab and elsewhere could be made, as well as good verification of some of the predicted requirements.

Presentations were made to the committee about the needs of present and future experiments at CERN (UA1, LEP-3) and SLAC (TPC) and the plans made by CDF in preparing to meet their needs. In addition, presentations were made on the plans of the Computer Department and the Advanced Computer Project. The committee conducted a survey of users (HEP experimentalists, theorists, and accelerator physicists and engineers) in order to estimate the computing load predicted to occur over the next few years.

Results from Survey

The basic conclusion from the survey of users was that the raw computing power necessary will rise to approximately 7 Cyber-175 equivalents in 1984 and to 24 Cyber equivalents by 1987. These numbers have, of course, large uncertainties on them, but, even if only partially correct, do indicate that an enormous increase in the demands put upon the Computing Center is imminent. Several major factors contribute to this predicted increase:

(a) The advent of the Collider and the two experiments, CDF and D0. Together these two experiments are predicted to account for 65% of the total load by 1987. This number already assumes that the data rate has been considerably reduced from the enormous interaction rate before writing data onto magnetic tape. Sophisticated hardware and software trigger processors, themselves having comparable computing requirements, will be necessary to perform this function.

(b) Most fixed-target experiments have increased in complexity, having increased the number of detector channels and the trigger rate. In many cases the experiments are now second generation and are therefore, because of their nature, more complex.

(c) Enhancements to the beam lines will enable several previously mutually exclusive experiments to coexist.

(d) Extensive studies of the performance of the Antiproton Source and Collider will soon be necessary.

(e) Fermilab will be heavily involved in the design and construction of the new Multi-TeV pp collider. This machine will require a very intensive program of lattice calculations and magnet design in order to produce a technically feasible solution that satisfies budgetary constraints.

It is the general feeling of the committee members that such an enormous computing load will not be cost-effectively met by a "mainframe" in an adequate timescale and that by mid-1986 one could have a central processor that would handle approximately half this load. The remainder of the task will probably have to be performed using super-mini computers, single-board programmable microprocessors or emulators. Care must be taken to provide an adequate environment by which these diverse technologies may be integrated into a useable whole.

The survey mainly addressed "capacity" rather than "capability." Capacity may be thought of as the number of CPU cycles, disc drives, and tape drives. Capability is the number of special input and output devices, number of large jobs that can be run in parallel, variety of the types of work that can be performed such as interactive graphics, and the quality of interactive computing. The committee members feel that more emphasis should be given to addressing the aspects of computing associated with increasing the capability of the Fermilab Computing Center.

Computing Tasks and the Computing Environment

In bringing a HEP experiment to a successful conclusion there are many diverse computing tasks that must be performed. Some of these, such as performing the main data reduction, stress the traditional batch role of a computer center. This also means that they are suitable for more unconventional, cost-effective means of solution such as multiple single-board microprocessors or emulators. Other tasks, such as program development and physics analysis, require a more high-level interactive environment.

Although the size of major HEP experiments is increasing enormously, both in the number of electronic channels (100k-300k) and the number of physicists involved (100-250), the development of the software base falls to a relatively small number of people. Thus the quality of the computing environment plays an increasingly important role in determining whether an experiment will be ready on time. The particular aspects that are important here are the level of interactiveness for program development and the integration of different sections of the computing environment into a collective ensemble. Thus editing, file handling, job submission, interactive debugging, system monitoring, and code and database portability are the important areas rather than just raw computing power.

The committee has put forward a senario that has the following components:

(a) A large mainframe. This need not be a single processor, but should present a single system image to the user, such that he need not concern himself with which processor he is communicating with or on which one the jobs he submits will run. Essential features of such a "mainframe" are the provision of sufficient user-addressable memory (several megabytes) as well as sufficient physical memory to allow several such user jobs to run concurrently efficiently. It must have facilities for including the machine in a network, with particular emphasis on connection to VAX computers used as data-acquisition computers. Such a connection should provide adequate hardware and software support for transfer of both programs and databases.

(b) Banks or "farms" of special-purpose processors for "number crunching." Such farms can provide significant computing power for relatively stable production jobs. However, access must be flexible because it is highly unlikely that programs will remain completely stable throughout the life of an experiment. The emphasis here is on adequate software support to enable both programs and databases to be developed, downloaded, and verified.

(c) Distributed VAX computers. These exist primarily for data-acquisition purposes. Given the correct environment, such computers could form a considerable resource if they are stable for the lifetime of an experiment. This would enable them to be used, not only for data acquisition, but also for some off-line work and local development of special trigger processors etc. The emphasis here is on a sufficient level of networking.

(d) Personal work stations. These may take the form of specialized graphics devices, stand-alone computing systems, or integrated networking systems. State-of-the-art workstations are currently not available from the major manufacturers, although both IBM and DEC have just announced offerings approaching this level. They have the potential to revolutionize a major part of computing within HEP. Major portions of the physicist's data analysis, calculation, and document-preparation tasks could be entirely removed from the province of centralized computing.

(e) Home-institution computers. Most of these are VAXs and have the potential of providing considerable computing resources.

(f) Networks connecting the various elements of this computer ensemble. Crucial are both high-speed links between computers on-site, and also slower speed links to the outside world, so as to enable physicists from their home institutions easy access, not only to the main computer center, but also to their data-acquisition computer.

The effectiveness of such a computer system will depend very heavily on the software support in order to present to the user a uniform image. Important criteria are:

(a) Does the environment provide an efficient means for performing all the essential data-taking, reduction and analysis-related jobs?

(b) Are the hardware facilities fully utilized without unduly sacrificing convenience or quick availability?

(c) Are the facilities sufficiently centralized to allow efficient use of manpower? Conversely, if distributed, are the overall hardware and software maintenance tasks reasonable?

(d) Does the environment function as a flexible, integrated whole? Can the user choose a part of the total system best suited to a particular task efficiently and not be

subjected to excessive "overhead?" Will he have to prepare specially formatted input or output files, or have to transport large amounts of data across slow and unreliable links?

Implicit here is a high level of networking, both locally on the Fermilab site, and also efficient links to collaborating institutions, not only here in the USA, but also to Europe and Japan. Such networking should provide a high degree of transparency and provide the user with protocols for both computer-computer and terminal-computer interaction. When dealing with diverse machine architectures, the support hardware and software should attempt to minimize the "pain" to the sensible user in the number of restrictive rules that he must self-impose.

Implementing such a computer system will place great demands on the computer department since more effort will need to be expended in areas unconnected with the normal day-to-day activities. Study groups should be set up in order to evaluate alternatives in critical areas such as workstations and networks. Compatibility, both of programs and databases, across diverse machine architectures will become increasingly important and will entail detailed study.

Recommendations

Several recommendations have been made by the committee as concluding remarks in its report to the Director. The main ones may be summarized:

1. Significant additional computing capacity and capability should be provided by 1986. A working group with representation from the principal computer-user community should be formed to begin immediately to develop the technical specifications. High priority should be assigned to providing a large user memory and software portability as well as a productive computing environment.

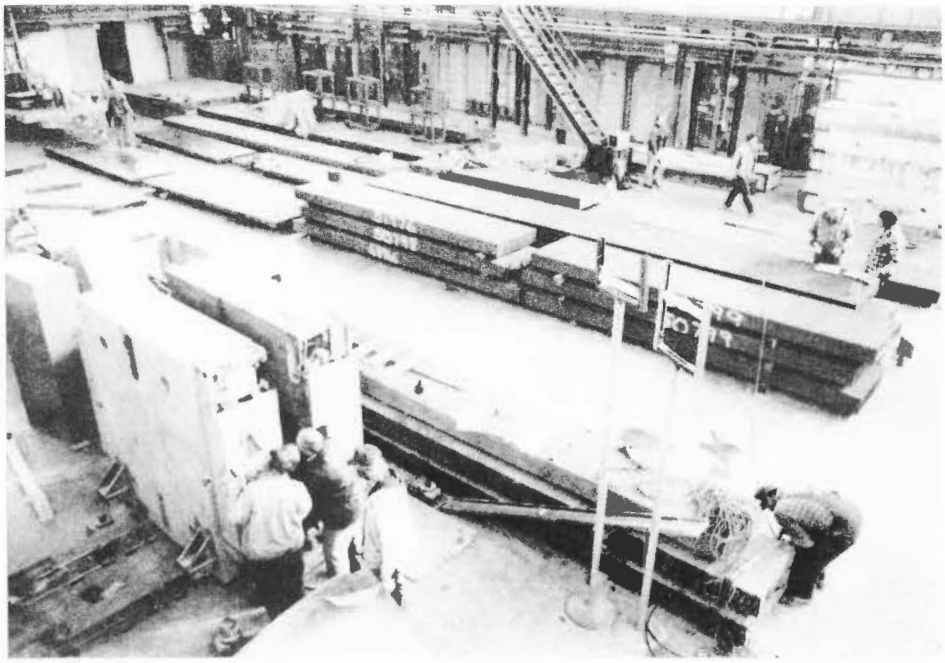
2. The Laboratory should move decisively to a more fully interactive environment.

3. A plan for networking both inside and outside the Laboratory should be developed over the next year.

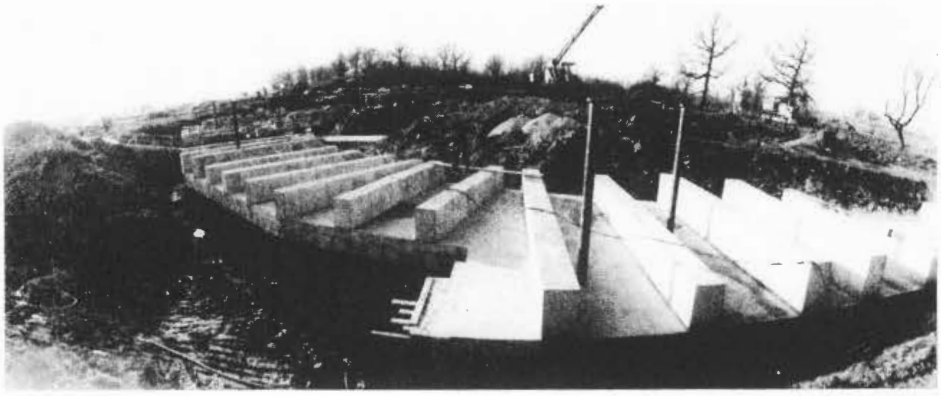
4. The Laboratory resources devoted to computing, including manpower, should be increased over the next few years. A reasonable increase would be 50% over the next two years, increasing thereafter to a level of about twice the present one.

5. A standing computer-coordinating group, with membership from all the principal computer-user constituents of the Laboratory, should be appointed. This group should regularly review all aspects of the computing environment, assist the Director in keeping the user community well informed, and define and manage working groups set up to pursue special development projects.

Several of these recommendations have already been, or are in the process of being acted on. Action on all areas identified in the report should have profound effects on both the amount of raw computing power available and also on the quality of life as a computer user.



Steel shielding being installed in the M3 beam line.
(Photograph by Fermilab Photo Unit)



Construction progress on the Antiproton Source Ring Tunnel.
(Photograph by Fermilab Photo Unit)

TAIJI YAMANOUCHI AWARDED NISHINA MEMORIAL PRIZE

Taiji Yamanouchi, Fermilab Assistant Director and Head of the Program Planning Office, was selected to receive the 1983 Nishina Memorial Prize at a ceremony held in Tokyo on December 6. This prize is given to Japanese physicists who have performed distinguished work in the field of atomic and nuclear physics. Dr. Yamanouchi was awarded the prize for his accomplishments in high-energy physics research, including his contribution to the discovery of the upsilon particle in Fermilab experiment E-288.

Dr. Yoshio Nishina was a prominent Japanese physicist who is well-known for the Klein-Nishina formula on electron-photon interactions, and also is recognized as being the founder of modern Japanese physics in the 1920's.

Taiji Yamanouchi

A delegation from the People's Republic of China visiting Fermilab on November 21.

(Photograph by Fermilab Photo Unit)