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Memorandum L-6

SUBJECT: COMPARISON BETWEEN THE COMPUTER PROGRAMS AT THE INSTITUTE FOR ADVANCED STUDY AND THE M.I.T. SERVOMECHANISMS LABORATORY

From: Jay W. Forrester and Robert R. Everett

Date: October 11, 1948

On October 5 we visited the Institute for Advanced Study to discuss with them their work on digital computers. Both I.A.S. and M.I.T. are working on parallel-type digital computers. Beyond this, the two groups hold very few common views on the methods for specifically achieving working equipment.

The differences between the two groups result primarily from a different basic philosophy and ultimate objective. The activities of each group seem to fit well with their expression of principles underlying the work.

IAS is presently engaged in constructing what is essentially a breadboard model of a computer. It is their feeling that sufficiently little is known about high-speed computers in the several fields of component design and integration, reliability, and problem setup and codes to make unwise any attempt at this time to build any sort of a final model. In consequence they have gone about the design of as simple a computer as they could of the general type in which they are interested. Wherever necessary, they have given up speed and flexibility in the interests of this simplicity. It is their plan to use their computer less as a first approximation than as an exploration. Once the machine is available they fully expect that they may discover so much about its use and maintenance as to drastically affect any further designs.

The future of their computer design program is much in doubt. They are primarily users in the field of scientific calculation. In this field computer specifications are nebulous and can be much less strict than in other fields. This is particularly so since as users they are also presently interested mostly in exploration. Consequently, a machine with relatively poor reliability (perhaps operation 50% of the time) and a speed only a tenth as fast as presently seems possible (but still 104 as fast as hand calculation) may well serve their purposes by providing a computing capacity much greater than they can at present use. If their first machine fits these requirements, they might content

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themselves with it for a period of years, maintaining it in their Laboratory by the sympathetic attention of its designers. If the machine fails to meet these requirements, they might continue almost immediately into a new design or extensive modification considering their present breadboard as expendable.

Their approach is therefore essentially leisurely, step-by-step, in computer language, serial. Their staff is small, their designs are simple. They make sincere efforts to obtain speed, flexibility, and reliability, but compromise where necessary. Since they are engaged in what is essentially an experiment, they are not particularly interested in reporting on the construction of their experimental equipment, nor in integrating that equipment with other existing equipment nor in training people for the use of machines which to them seem the possible result only of many future experiments.

In contrast to this approach, MIT is building what can more correctly be called a prototype and not an experiment or breadboard. The specifications given MIT and substantiated by their own investigations are much more strict and much better known than those of IAS. On the basis of considerable study MIT has reached a fairly firm conclusion as to the nature of the computer needed. MIT has consequently started construction of a computer with this nature. Since it is here also recognized that much is still to be learned that can only be learned from this machine itself, this computer is not a final design but a prototype. This prototype is being built as near to the presently foreseen needed characteristics as possible with the following difference. Great flexibility is being built in, every facility for easy study, maintenance, and modification is being provided. Wherever compromise on specifications has been necessary, it has been made only with provision for later improvement and without relaxing the specifications for other elements. Where necessary to test specifications special component research has been undertaken. Elaborate and sometimes redundant trouble-location and prevention equipment has been designed. The intention is that the prototype should embody as many as possible of the desired features and characteristics, and to insure this the prototype will probably include many which are not needed. The IAS approach is to attain the desired goal by an iterative procedure, the first step of which is a bold attack aimed in the estimated direction. The MIT approach is to estimate the goal more exactly and then to flood or saturate the area surrounding that estimate in a complex attack.

To be sure, the MIT approach is less efficient and more expensive, but it should be faster. Speed in the attainment of usable computers seems of great importance under present conditions.

The above comments might be rephrased more simply by saying that IAS is engaged in scientific research, the goal of which is the study of high-speed computing technique while MIT is engaged in engineering development, the goal of which is to produce and use computers.

The differences between these principles can probably best be expressed by following the form of my Memorandum L-5 of October 3 which outlines in greater detail the objective of the Servomechanisms Laboratory.

A. Difference in Laboratory Approach

1. Systems

MIT is principally interested in systems and the problems which arise in the coordination of new components into operating equipment. LAS has thus far restricted its attention to component development and does not yet seem to have faced the problem of combining these components into a working computer.

2. Training

At MIT some 30% of the staff is on short-term, rotating academic appointment which contributes to the desperately critical training of new personnel.

The LAS employs a small permanent staff and is making no substantial contribution to the training of new persons in the computer field.

3. Continuity

At MIT continuity of the work is considered important and much attention is given to accurate drawings and complete technical reports. These are circulated throughout the country to all interested persons who have need either for the classified or unclassified results of the work.

The LAS does little reporting on the technical aspects of their computer. No printed information on such has been available at MIT. They have written certain valuable reports on arithmetic methods for the solution of mathematical problems, as well as a report giving a general description of their machine.

4. Specifications

MIT is holding to the original computer specifications for speed and performance, believing that these objectives must eventually be met when the computers are used in control applications.

The LAS believes that it is more important to obtain any type of machine as quickly as possible. For their major interest which is in mathematical computation, the ultra high speeds are not necessary at the present time.

5. Flexibility

The Project Whirlwind design provides great flexibility in rearranging control sequences and machine operations as may be found necessary in the future.

The IAS is following the opposite approach and will plan a minimum central control and redesign as found necessary.

6. Operational Design

MIT is following a two-dimensional electronic layout on flat panels which allows complete accessibility to components. Design standards are those common to radar and military electronic systems.

The IAS is making complete use of three dimensional arrangement thereby making the components inaccessible, but at the same time simplifying the power and line driving problems which arise in a larger machine. The IAS depends heavily on soft soldered electrical connections for mechanical support, and there is reason to doubt that their circuits can be extended to operational packaging without beginning with new circuit research.

7. Reliability.

MIT would consider 50% reliable operation as a minimum acceptable even for the prototype equipment while the IAS would consider 50% operation as excellent and very fortunate.

8. Component Development.

In connection with its computer work MIT is devoting 30% to 40% of its laboratory effort to the development of components which have useful application to other computers and outside the computer field. These include storage tubes, pulse transformers, new gate tubes, test equipment, and in cooperation with Sylvania some work on crystal diodes.

The IAS is relying on available components and compromising speed and performance as necessary to avoid related developments. Including the work done at the Bureau of Standards, IAS has the manual television equipment in a fairly advanced development state than MIT.

V. CONTACTS BETWEEN IAS AND MIT GROUPS.

1. Computer Applications.

The MIT group believes that digital computers will have urgent and rather immediate importance in civilian and military control problems.

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The IAS is primarily interested in computers for mathematical computation and apparently has not given serious consideration to their control importance. At MIT we believe that control applications are the ones exhibiting the greatest engineering and monetary value and that computers for mathematical and scientific work will be obtained as a by-product from the effort.

2. Control Application.

The MIT work is directed at the present time at the aircraft analyzer which is typical of many possible simulation problems and the equipment for which is similar to that required in control applications.

The IAS machine will apparently be for their own laboratory studies and mathematical problems. Since it appears likely that their interest in mathematical studies will overshadow their interest in machines, it is likely that their development program will cease with this first equipment. Their program does not, therefore, provide continuity which will be essential to rapid progress in computers.

3. Urgency.

MIT believes that the development of digital equipment for military control is important in connection with other military research now in progress.

IAS being primarily interested in scientific applications will probably take a more leisurely course.

4. Reliability.

At MIT the greatest problem in digital computers is believed to be that of reliability. Two large electronic machines, the ENIAC and the IBM computer, now exist and show such poor reliability that they cast a doubt on the use of digital computers in control applications. We feel that the major problem is, therefore, to build equipment and develop for it the trouble-location and maintenance procedures that will permit high reliability and rapid servicing.

The IAS being interested in laboratory applications is perhaps justified in discounting the reliability importance and can continue to follow the road of other existing electronic machines.

5. Speed.

MIT considers computer speed to be of primary importance because many control and simulation problems are shown to require either high-speed or several computers operating on the same problem. Using several computers leads to complexity of equipment and serious problems of automatic computer interconnection and places a premium on speed in a single computer.

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IAS being primarily interested in scientific computations can relate their speed requirements to the problems of input-output equipment and desired ratio of computing speed to manual problem setup in time.

6. Storage Tubes.

MIT is devoting a large part of its effort to electrostatic storage tubes. Thus far, IAS has done almost no work in storage. They were first planning to use the RCA electron tube, but early this year became discouraged with delivery prospects and transferred their plans to the interim use of magnetic drum storage as is being planned in the Mark III Computer at Harvard. More recently they have changed again to considering the electrostatic storage tube developed by Williams in England which shows a fair promise as an interim storage device, but so far as we know has not yet been carefully investigated.

7. Reports.

MIT makes a substantial effort in reporting all phases of its work while most activity at IAS is unavailable except as obtained by personal visit.

8. Computer Systems.

MIT designs continuous extension of digital computers to the control systems in which they will eventually be used. IAS is restricting its work to purely laboratory equipment on a physical design which may not be extendable to operational design.

9. Overall Responsibility.

MIT has undertaken responsibility, along with Sylvania and Eastman contracts, for all phases of the computer program. Thus far, the IAS has not decided the sort of storage to be used and has been relying on the work of other groups in this field. Furthermore, they have not yet undertaken design or construction of the central control of the computer which in MIT experience is a more difficult job than those phases which the IAS has worked on. At MIT a complete plan for the machine was available before starting its design. The burden of this work was in planning the machine control. This was followed by the arithmetic element and by the input-output equipment. The Institute for Advanced Study has approached from the opposite direction, working first on input-output equipment and then on the arithmetic element and have not yet reached the central control or storage problems. Neither have they done substantial work in the interconnection of machine components.

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